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Assessments of Atlantic salmon stocks in southwest New Brunswick, an update to 2003

Évaluations des stocks de saumon atlantique du sud-ouest du Nouveau Brunswick : bilan jusqu'à 2003

R.A. Jones[1], L. Anderson[2], T. Goff[2]

[1]Department of Fisheries and Oceans
Science Branch, Maritimes Region
P.O. Box 5030
Moncton, NB E1C 9B6

[2] Department of Fisheries and Oceans
Science Branch, Maritimes Region
Mactaquac Biodiversity Facility
Kingsclear, NB E3E 2C6

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ABSTRACT

Total one-sea-winter (1SW) (1,304) and multi-sea-winter (MSW) (752) returns destined for upstream of Mactaquac Dam on the Saint John River in 2003 were the second and third lowest, respectively, in 34 years of record. Hatchery-origin fish comprised 71% of 1SW and 68% of MSW fish with the MSW percentage being the highest on record. Return rates for hatchery-released smolts were 0.0034 (1SW) and 0.0015 (2SW), a decrease of 24% and an increase of 317%, respectively, from the values in 2002. Spawners numbered 1,136 1SW and 555 MSW salmon, 23% and 11% of the respective requirements. The egg deposition estimate (31% from wild fish) was 12% of the requirement, double the value estimated in 2002.

Counts at the Nashwaak River fence resulted in a return of 297 1SW and 113 MSW salmon. Return rates for wild smolts to 1SW and 2SW fish in 2003 were 0.0191 and 0.0090, a decrease of 39% and an increase of 385%, respectively, from the previous year. Spawners represented 14% and 5% of the respective 1SW and MSW conservation requirements. An egg deposition of 7% of the requirement was the second lowest since operation of the fence recommenced in 1993.

Fishway counts from the Magaguadavic and St. Croix rivers were 29 (including seven post smolts) and 24 salmon, respectively. Including the post smolts, thirty-two or 60% of the combined counts were deemed of aquaculture origin and denied access to both rivers. On the Magaguadavic River, 3 1SW and 3 MSW wild salmon were released upstream of the fishway which resulted in an estimated egg deposition of about 2% of the requirement. All hatchery salmon, 6 1SW and 9 MSW fish, ascending the St. Croix River at Milltown were retained for the hatchery program. For the sixth consecutive year no wild or hatchery returning salmon were released to spawn upriver of Milltown Dam.

Projected returns, based on the average returns of the previous five years, for populations originating upriver of Mactaquac Dam on the Saint John River in 2004 are 2,340 1SW (90% C.I.; 960 - 3,720) and 940 MSW (90% C.I.; 180 – 1,890) salmon. The probabilities of attaining the conservation requirement of 4,900 for both 1SW and MSW fish are near zero. Without a significant increase in marine survival, it is very unlikely that returns will provide even one-quarter of the conservation egg requirement in 2004.

Based on the five year average, 410 1SW (90% C.I.; 140 - 690) and 190 MSW (90% C.I.; 50 - 330) salmon are predicted to return to the Nashwaak River in 2004. Using the range (minimum and maximum) of smolt-to-1SW return rates observed since 1999 to the 2003 wild smolt estimate, the predicted 1SW returns to the Nashwaak in 2004 are more likely to be between 140 and 280 fish. Similarly, the predicted 2SW salmon return in 2004, from the 2002 smolt class, ranges from 40 to 130 fish. The probability of attaining the conservation requirement of 2,040 for both 1SW and MSW salmon is therefore near zero.

Wild and hatchery 1SW and MSW salmon returning to the Magaguadavic and St. Croix rivers in 2004 are projected to be no greater than the few fish that returned in 2003. There is a zero probability of attaining the conservation requirement in 2004.

RÉSUMÉ

Le nombre total de saumons unibermarins (UBM) (1 304) et pluribermarins (PBM) (752) dénombrés en 2003 au barrage de Mactaquac, dans la rivière Saint-Jean, se situaient respectivement au deuxième et au troisième rangs des remontes les plus basses en 34 ans. Les saumons d'écloserie constituaient 71 % de l'ensemble des UBM et 68% des PBM, ce dernier pourcentage étant le plus élevé enregistré. Le taux de retour des smolts d'écloserie se chiffrait à 0,0034 et 0,0015 respectivement pour les UBM et les DBM, ce qui représente une baisse de 24 % et une hausse de 317 % respectivement par rapport aux valeurs pour 2002. Le nombre de reproducteurs se chiffraient à 1 136 UBM et 555 PBM, soit 23 % et 11 % respectivement des impératifs de conservation. La ponte estimative (assurée à 31 % par des saumons sauvages) a satisfait 12 % de l'impératif de conservation, soit le double du pourcentage estimé pour 2002.

Les dénombrements réalisés à la barrière de la Nashwaak ont recensé 297 UBM et 113 PBM. Le taux de retour des smolts sauvages à l'état d'UBM et de DBM en 2003 se chiffrait respectivement à 0,0191 et 0,0090, ce qui représente une diminution de 39 % et une augmentation de 385 %, respectivement, par rapport à l'année précédente. Les reproducteurs ont satisfait 14 % et 5 % des impératifs de conservation respectifs pour les UBM et les PBM. Seul 7 % de la ponte requise a été obtenu, ce qui est la deuxième plus faible valeur depuis que la barrière a recommencé à être tenue en 1993.

Les dénombrements réalisés aux passes migratoires des rivières Magaguadavic et Ste-Croix ont recensé 29 (dont sept post-smolts) et 24 saumons, respectivement. Y compris les post-smolts, 32 ou 60 % du total des saumons dénombrés ont été considérés comme d'origine aquacole et n'ont pas été remis à l'eau. Dans la Magaguadavic, 3 UBM et 3 PBM sauvages ont été remis à l'eau en amont de la passe migratoire, ce qui a résulté en une ponte estimative d'environ 2 % de la ponte requise pour la conservation. Tous les saumons issus d'écloserie, soit 6 UBM et 9 PBM, capturés dans la Ste-Croix à la hauteur de Milltown, ont été gardés comme stock reproducteur. Pour la sixième année consécutive, aucun saumon sauvage ou d'écloserie amontant n'a été remis à l'eau pour qu'il puisse frayer en amont du barrage de Milltown.

Les remontes prévues en 2004, reposant sur les remontes moyennes durant les cinq années précédentes, pour les populations retrouvées en amont du barrage de la Mactaquac dans la rivière Saint-Jean, sont de 2 340 UBM (I. C. à 90 % : 960 – 3 720) et de 940 PBM (I. C. à 90 % : 180 – 1 890). Les probabilités que les impératifs de conservation – qui sont de 4 900 UBM et du même nombre de PBM - soient satisfaits sont pratiquement nulles. Sans une nette amélioration de la survie en mer, il est très peu probable que les remontes soient suffisantes pour satisfaire même 25 p. 100 de la ponte requise pour la conservation en 2004.

D'après la moyenne quinquennale, les remontes prévues dans la Nashwaak en 2004 sont de 410 UBM (I. C. à 90 % : 140 - 690) et de 190 PBM (I. C. à 90 % : 50 - 330). D'après la fourchette des taux de retour (minimum et maximum) des smolts à l'état d'UBM observés depuis 1999 par rapport à la production estimative de smolts sauvages en 2003, il est plus probable que la remonte d'UBM dans la Nashwaak en 2004 se chiffrera entre 140 et 280 saumons. De même, la remonte projetée de DBM en 2004, issus de la classe de smolts de 2002, varie entre 40 à 130 saumons. La probabilité que l'impératif de conservation de 2 040 UBM et PBM sera satisfait est donc presque nulle.

On ne prévoit pas que le nombre d'UBM et de PBM sauvages et d'écloserie qui reviendront dans la Magaguadavic et la Ste-Croix en 2004 sera supérieur aux quelques saumons qui y sont revenus en 2003. La probabilité que l'impératif de conservation soit satisfait en 2004 est nulle.

INTRODUCTION

This document assesses the status of Atlantic salmon (*Salmo salar*) populations for the **Saint John River upriver of Mactaquac Dam**, the **Nashwaak River** (a tributary to the Saint John River downstream of Mactaquac Dam), the **Magaguadavic River** and the **St. Croix River** of southwest New Brunswick in 2003. These salmon populations, collectively called the outer Bay populations of the western part of SFA 23, are bordered on the east by the "endangered" inner Bay of Fundy populations and on the west by the United States "endangered" populations of eastern Maine. These outer Bay populations have also declined significantly and have failed to meet egg conservation requirements for 15 or more years.

Data and analyses of Saint John River populations pertain primarily to populations originating upriver of Mactaquac Dam and the Nashwaak River. Data collections were made possible to a large extent because of collaborations with the Tobique Salmon Protective Association, Nashwaak Watershed Association, NB Power, as well as Kingsclear, Woodstock, Oromocto and Tobique First Nations. The data for the Magaguadavic River were provided by the Atlantic Salmon Federation and data for the St. Croix River were provided by the St. Croix International Waterway Commission.

Projected returns for populations originating upriver of Mactaquac on the Saint John River in 2003 were 3,070 1SW and 980 MSW salmon with probabilities of less than 1% of attaining the conservation requirement. Predicted returns to the Nashwaak River in 2003 were 600 and 230 1SW and MSW salmon, respectively. The estimated smolt output from the Nashwaak in 2002 along with the average smolt-to-1SW return rate, suggested that 1SW returns in 2003 would be as few as 350 fish. Wild and hatchery 1SW and MSW returns to the Magaguadavic and St. Croix rivers in 2003 were projected to be no greater than the few fish that returned in 2002 with a near-zero probability of attaining the conservation requirement.

Many of these outer Bay populations face a multitude of constraints including hydroelectric dams (with upriver passage facilities but mostly devoid of safe downstream passage), artificial flow regimes, headponds, significant industrial and municipal effluents, run-off from intensive agricultural operations, and developing communities of invasive predators (i.e. muskellunge, small mouth bass and rainbow trout). As well, juvenile and adult salmon escapes from the Fundy-Isle (NB) or Cobscook Bay (ME) aquaculture facilities are the most probable sources of aquaculture origin salmon escapes identified at all primary counting facilities.

SAINT JOHN RIVER UPSTREAM OF MACTAQUAC DAM

Physical attributes, salmon production area (updated in Marshall et al. 1997), barriers to migration, fish collection and distribution systems, the role of fish culture operations and biology of the populations of the Saint John River drainage (Fig. 1), have been previously described in Marshall and Penney (1983). The status of the salmon populations since 1970 were estimated beginning in 1983 (Penney and Marshall 1984) and continued through to 2002 (DFO 2003a). The last detailed stock assessment document was completed in 1997 (Marshall et al. 1998) with less detailed assessment documents for the 1998 (Marshall et al. 1999a and Marshall et al. 1999b) and 1999 (Marshall et al. 2000) returns. Stock status since 2000 has been reported in the Atlantic Salmon Maritime Provinces Overviews (DFO 2001, DFO 2002, and DFO 2003a). The approach in this assessment of populations in southwest New Brunswick is similar to that of 1997 (Marshall et al. 1998).

Description of fisheries

The entire Saint John River has been closed to commercial fishing for Atlantic salmon since 1984, and the persistent failure of populations to achieve the conservation requirement has resulted in complete closures of the Aboriginal food and recreational fisheries since 1998. The recreational fishery has been closed since 1995 with the exception of a hook and release fishery that occurred from July 15 – August 12, 1997 (Marshall et al. 1998).

The Maritime Provinces' commercial salmon fishery has been closed since 1984 and, after several buy-backs of licences, has only four eligible licences remaining in the Saint John River area. The moratoria on commercial salmon fisheries since 1992 in insular Newfoundland and since 1998 in Labrador both continued in 2003. An Aboriginal subsistence fishery continues in Labrador and harvested 17.5t of salmon in 2002 (DFO 2003b). Commercial salmon fishing off West Greenland was suspended again in 2003 although a subsistence fishery harvested 9 tonnes of salmon in 2002 (ICES 2003).

Returns destined for Mactaquac

Methods

Total returns of 1SW and MSW salmon (wild and hatchery origin) from upstream of Mactaquac Dam are the sum of 1) the counts at Mactaquac, 2) estimates of removals in the main stem downstream of Mactaquac Dam, and 3) the assumed by-catch in May and early-June in downriver shad and gaspereau net fisheries.

Counts at Mactaquac consist of fish captured at the fish collection facilities at the Mactaquac Dam and at the smolt migration channel at the Mactaquac Biodiversity Facility. During 2003, the fish collection facilities at the Dam and the migration channel at the Biodiversity Facility were operated from May 21 to November 4.

At the fish sorting facility at the Mactaquac Biodiversity Facility, returning salmon were classified as being either of wild-origin, hatchery-origin or aquaculture escapes. Hatchery-origin salmon that were released as 1-year smolts at the smolt migration channel at the Mactaquac Biodiversity Facility or as juveniles (essentially fall parr) released upstream of Mactaquac, were principally identified by the absence of an adipose fin. Some returns were classified as hatchery-origin in spite of the presence of an adipose fin. These fish had obvious fin erosion and interpretation of scale patterns did not suggest an aquaculture escape. Suspected aquaculture escapes were identified by erosion and partial regeneration of fin rays on the upper and/or lower lobes of the caudal fin as well as the presence of an adipose fin. Interpretation of scale samples from all suspected aquaculture escapes was also used in determining their origin. All other fish were classified as wild-origin. Returns from hatchery-origin unfed and feeding fry were more likely to have unclipped, un-eroded fins, are therefore indistinguishable from wild-origin fish, and are misclassified using these criteria.

Marshall and Jones (1996) described the difficulty in distinguishing between adult returns from natural versus artificial recruitment because of the increasing numbers of unmarked hatchery distributions in the early and mid 1990's. Since 1998, the majority of the fall fingerling parr and spring smolts released upstream of Mactaquac have had the adipose fin removed (Appendix *i*, Fig. 2). Scale samples are taken from approximately every fifth hatchery grilse, every fourth hatchery salmon and every second wild fish (exceptions included the complete sampling of all broodstock). The proportion of wild- and hatchery-origin in the count was adjusted based on interpretation of these scales. The procedures used to adjust counts in 2003 are identical to those used since 1995 and described in Marshall and Jones (1996). The adjusted

counts at Mactaquac were used to estimate the returns and return rates for hatchery fish released as age-1 smolts and some age 0+ parr.

As in 2002, salmon by-catch in the lower river and in the Saint John Harbour was monitored by DFO fishery officers. Consistent with previous assessments, the assumed catch rates were 1% of the 1SW and 2.5% of the MSW river returns. Catches of salmon destined for upstream of Mactaquac Dam and caught downstream of Mactaquac were assumed to consist of hatchery and wild origin salmon in the same proportions as the adjusted counts at Mactaquac.

Results

Counts of salmon at Mactaquac in 2003 totalled 1,281 1SW and 743 MSW salmon (Tables 1 and 2). Ten (1.3%) of the 743 salmon counted at Mactaquac were reassigned to 1SW category on the basis of scale interpretation (Table 1). Interpretation of scales shifted the hatchery component among 1SW fish from 65.3% (Table 1) to 70.8% and among MSW fish from 62.5% to 68.0%. The adjusted counts proportioned by age composition among hatchery and wild components since 1995 are tabled in Appendix *ii*. Three aquaculture escapes were identified in 2003.

There were no reports of illegal fishing in the main stem downstream of Mactaquac Dam in 2003. An estimated 13 1SW and 19 MSW salmon were ascribed to by-catch in the shad and gaspereau nets in the lower river and Saint John Harbour area (Table 1).

Estimated adjusted wild-origin and hatchery-origin returns in 2003 were 1,302 1SW and 751 MSW fish (Table 1; Fig. 3). One-sea-winter returns were the second lowest estimate since 1970 while MSW returns were the third lowest in a 34-year time series (Table 3). Adjusted returns of wild-origin 1SW salmon were down from those of 2002, only accounted for 55% and 30% of the previous 5- and 10- year means, respectively, and were the third lowest in a 34-year time series (Table 3). Adjusted returns of wild-origin MSW salmon were the second lowest in 34 years and were 53% and 20% of the respective 5- and 10- year means (Table 3). The return rate of 1-year smolts as 1SW fish destined for Mactaquac was 0.00340 - the second lowest on record (Table 4a; Fig. 4). The return rate of 1-year smolts as virgin 2SW salmon (Table 4b; Fig. 4) was 0.00149 - three times greater than the rate in 2002 but similar to 2001.

Removals of fish destined for Mactaquac

Methods

Removals from the potential spawning escapement destined for the traditional production areas upstream of Mactaquac include: 1) the estimate of 1SW and MSW salmon ascribed to by-catch in the estuary, 2) salmon passed or trucked upstream of Tinker Dam on the Aroostook River (Fig. 1), 3) salmon held at Mactaquac as broodstock, and 4) estimated to have been lost to poaching/disease, or handling operations at Mactaquac.

Losses to poaching and disease include those estimated to have been taken in the net fishery on the Tobique River, and known mortalities from fishways (Beechwood, Tobique and/or Tinker Dam) or Tobique Half Mile Barrier Fence. If detailed information was not available for the losses, they were apportioned to hatchery/wild components on the basis of known or estimated stock composition of fish released upstream of Mactaquac.

Results

Reports from area fisheries officers indicated that there was illegal fishing activity near Tobique Narrows Dam in 2003 but the number of fish harvested was unknown. So a fishing mortality estimate, derived from a fishway efficiency study in 1999, was applied to the number of fish passed upstream of Beechwood Dam and translated to 19 fish in this illegal fishery. Forty-

nine 1SW salmon were transported from Mactaquac to the Aroostook River upstream of Tinker Dam, while an additional one 1SW and one MSW fish ascended the Tinker Dam fishway (Table 5) to USA production area. The area upstream of Tinker Dam is excluded from the "upstream of Mactaquac" conservation requirement (Marshall et al. 1997).

Total river removals from all sources were estimated at 166 1SW and 196 MSW fish (Table 5) of which 84 1SW and 136 MSW salmon were held at Mactaquac for broodstock. These early-run broodstock yielded about 650,000 eggs.

Conservation Requirements

The conservation requirement is based on an accessible salmon-producing rearing area upstream of Mactaquac (excluding the Aroostock River) of 13,472,200 m^2 [>0.12% and <15.0% gradient (Amiro 1993); excludes headponds and 21 million m^2 of river with gradient <0.12%; (Marshall et al. 1997)]. Based on an assumed requirement of 2.4 eggs/m^2 (Elson 1975), the conservation requirement is 32,330,000 eggs. Using a length-fecundity relationship (eggs=430.19$e^{0.03605X\text{fork length}}$; Marshall and Penney 1983), and biological characteristics of 1SW and MSW salmon from 1988 - 1995 (1SW fish: 15% female, 59.6 cm fork length and 63% of escapement; MSW fish: 94% female, 77.6 cm fork length and 37% of escapement; Marshall et al. 1997), approximately 4,900 MSW fish are needed to achieve this requirement. The MSW salmon requirement was calculated on the basis of having a 1:1 male to female ratio.

Escapement

Collation of the total returns (Table 1) and total removals (Table 5) of wild and hatchery fish indicates that escapement was 555 MSW salmon and 1,136 1SW salmon (Table 6).

Differences in biological characteristics from 2002 were an increased proportion of females among hatchery 1SW salmon (+0.026) and a reduction in mean length (-2.1 cm). The proportion of females among wild and hatchery MSW fish increased by 0.050 and 0.098, respectively, from 2002 (Table 7). A decrease in mean length of wild (-2.2 cm) and hatchery (-1.7 cm) MSW spawners was observed between 2002 and 2003. Proportion female and mean length of wild 1SW spawners in 2003 was similar to 2002 and the previous 5-year mean. Mean lengths, length-fecundity relationship, and estimated escapement indicate that the total potential deposition was 3.91 million eggs (0.290 eggs per m^2) or 12% of the requirement. This is double the value estimated in 2002 (Fig. 5). Estimated eggs from wild and hatchery 1SW fish comprised 9.2% of the total deposition; estimated eggs from hatchery-origin 1SW and MSW salmon potentially contributed to 69.2% of the total deposition (Table 7).

The first adult releases from the captive-reared broodstock program initiated in 2001 were distributed to sites in the Tobique River and just downstream of the confluence with the main Saint John River near Perth-Andover in 2003.

Distributed to:	Date	Mature grilse
Tobique River		
Two Brooks	Oct 8 - 10, 2003	299
Pokiok Stream	Oct 10, 2003	40
Saint John River (Perth-Andover)	Oct 9, 2003	48
Total		387

Based on a mean length of 48.6 cm and assuming that these smaller freshwater reared fish have a similar length-fecundity relationship as the larger wild sea-run salmon (eggs=430.19$e^{0.03605X\text{fork length}}$; Marshall and Penney 1983), the 227 sexually mature "grilse-

size" females potentially produced another 560,000 eggs or an additional 2% of the conservation target. This egg estimate is very preliminary and will be updated once a relationship is developed for the Tobique captive-reared fish. To assess spawning, 20 males and 20 females were released to a 2.5 km stretch of river between two beaver dams on the Pokiok stream where surveys of redds and subsequent juveniles could be conducted. The redd survey was not conducted because of high water levels in late October/early November. The high flows likely allowed the fish to move outside the barriered stretch of river therefore preventing evaluation of spawning activity from the captive-reared releases. About 120 of the 299 captive-reared adults released near Two Brooks were counted by New Brunswick Department of Natural Resources (NBDNR) staff at the Tobique Half Mile Barrier before it was removed on October 20, 2003. Only one of the 49 captive-reared fish released in the main stem of the Saint John River near Perth-Andover was captured in the Tobique Narrows fishway, which was monitored by DFO staff until November 13, 2003.

In-river Ecological considerations

Discharges at Mactaquac from May to the end of July fluctuated about the mean value from 1996 to 2002 (Fig. 6). Plots of weekly 1SW salmon counts from the fish collection facilities at the Mactaquac Dam and from the smolt migration channel at the Mactaquac Biodiversity Facility indicate that the arrival time of 1SW salmon in 2003 was about one week earlier than the previous 10-year mean (Fig. 6). Higher than normal (1992 -2003 mean) weekly catches were observed for wild 1SW salmon during two weeks in August and one week in September for hatchery 1SW salmon. The majority of the MSW returns entered the fishway during warm water conditions in July when mean daily water temperatures were greater than 20 °C (Fig. 7). The peak arrival time for both the wild and hatchery MSW salmon returns in 2003 was about one week earlier than the 1993 - 2002 mean (Fig. 7). Since the majority of the fish were already counted by the end of July, the high discharge levels observed during the month of August did not appear to affect the overall run timing in 2003.

Parr Densities

Methods

Since 1999, at least 24 (mean=35) electrofishing sites have been monitored annually, principally in five tributaries upstream of Mactaquac. Assistance has been provided by First Nation and conservation groups located in communities within the watershed. Densities (number of fish per 100 m^2 of habitat) at these sites were, for the most part, derived using mark-recapture techniques. Total numbers of age-1+ and older parr were estimated using the adjusted Petersen method (Ricker 1975). Numbers of parr by age were determined from stratified sampling of large parr in 0.5 cm intervals. Generally a maximum of two parr were scale sampled for each length interval. The number of age-0+ parr or fry for the site was determined by applying the calculated capture efficiency for age-1+ and older parr on the marking pass (i.e. first sweep) to the number of fry captured during the marking pass.

Declining levels of juvenile salmon in the major tributaries of the Saint John River create difficulty in estimating juvenile densities using traditional methods (i.e. mark-recapture and depletion estimators). Gibson et al. (2003) were faced with a similar problem when attempting to determine densities from few captures of juvenile salmon for the "endangered" inner Bay of Fundy salmon populations. Gibson et al. (op. cit) used an empirical Bayes method to determine the probability of capture during the marking pass from a number of mark-recapture experiments. This same method was used to determine the mean capture probability for parr during the marking pass for the electrofishing surveys conducted by DFO within the Saint John River watershed. Data used in the analysis were collected from 1996 to 2003, representing close to 400 surveys. The mean capture probability was applied to sites done in 2003 in which

zero parr were marked or recaptured or if only the marking pass was completed. Prior to 2003, if zero parr were marked or recaptured then the mean capture efficiency for that river and year was used to determine the site density of fry and/or parr. For this document no adjustments were made to the pre-2003 site densities using the 1996-2003 mean capture probability.

To evaluate the status of juvenile salmon upstream of Mactaquac, densities of fry and parr were analyzed 4 ways: 1) mean of 21 sites done continuously since 1993, 2) weighted mean (based on habitat area as described in Marshall et al. (2000)) of 21 sites done continuously since 1993, 3) mean of all sites surveyed, and 4) weighted mean of all sites surveyed.

With the exception of the 2003 analysis (Table 8), the densities presented in this section of the document are for wild (or adipose fin present) parr only. For the most part, prior to 1998 all fall fingerling parr and unfed fry were released unmarked (Fig. 2) and suspected hatchery origin parr captured during electrofishing surveys were determined by observations of fin erosion or condition as made by field staff. Since 1998 (with the exception of 2000), most of the fall fingerling parr released have been adipose clipped and very few unfed fry were released (Fig. 2), thus making more certain the identification of wild parr.

Results

Analysis of the historical mark-recapture data using the empirical Bayes method determined that the mean probability of capture was 34.7% (5th and 95th percentiles 20.0 and 53.1%). This mean probability of capture was used for 10 of the 21 sites done annually since 1993 and for 19 of the 26 other sites electrofished upstream of Mactaquac in 2003 (Table 8).

The mean density of wild fry (age-0+) at 21 sites upriver of Mactaquac in 2003 was 1.0 fry per 100 m^2. Mean density weighted according to relative production area of the tributaries in which they are located was also only 1.0 fry per 100 m^2 (Fig. 8). Both values were the lowest mean densities estimated since 1993 and were consistent with the record low egg depositions estimated in 2002 (Fig. 5; Fig. 8). With the exception of 1995, mean densities at the 21 sites have been below the "Elson norm" of 29 fry per 100m^2 (Elson 1967). Similar trends were observed when using all electrofishing sites – the steady decline since 1995 and comparable annual fluctuations (Fig. 8). Mean densities from 1993 - 2003 of wild fry weighted by production area using all electrofishing sites were consistently lower than the mean densities for the 21 sites (Fig. 8). No wild fry were captured at 32 of the 45 (71%) electrofishing sites in 2003, further evidence of low escapement in 2002 (Table 8).

Mean density of age-1+ and older wild parr at the same 21 sites was 8.5 parr per 100 m^2 in 2003; mean density weighted according to relative production area was 6.0 parr per 100 m^2. These values are well below Elson's (1967) "normal index" of 38 small and large parr per 100 m^2 (Fig. 9). Although these values are double the mean density observed in 2002, they are the third lowest observed since 1993. From 1992 to 2003, the mean densities of age-1+ and older wild parr determined from all sites were similar to the mean densities calculated using the 21 sites (Fig. 9). Estimated parr densities from the Lockharts Mill and West Glassville sites on the lower section of the Shikatehawk River, which has not received juvenile hatchery supplementation since 1994, were high and above Elson norm levels (Table 8). Marshall et al. (1997) suggested that high juvenile densities in the Shikatehawk River, the first major tributary downstream of Beechwood Dam, may be a consequence of adults (particularly hatchery-origin) holding back and not migrating above Beechwood.

Tobique and Beechwood Smolt Investigations from 2000 - 2003

Spring smolt investigations upstream of Mactaquac, in collaboration with the Tobique Salmon Protective Association, NB Wildlife Trust and Atlantic Salmon Federation, have been conducted since 2000. Several sampling techniques and assessment methods are used. The objectives were: 1) to estimate the numbers of wild and hatchery smolts emigrating from the Tobique River, 2) to estimate the proportion of the total smolt output to have emigrated as spring smolts in conjunction with fall pre-smolt assessment activities, and 3) to obtain data on the spring migration patterns of the Tobique River smolts.

Methods

2000

Smolts were captured, marked, and released from a rotary screw trap or smolt wheel constructed by E.G. Solutions of Washington, Oregon. During 2000, the wheel was installed in the main stem of the Tobique River just downstream of the confluence of the Odell River (Fig. 10). The wheel was checked once daily except on weekends when it was checked on either the Saturday or Sunday. All smolts were identified for origin (wild – adipose present or hatchery – adipose clipped or in some cases fin erosion), measured for fork length and marked with numbered streamer tags. Approximately 20% of the smolts were scale sampled for later age determination. To estimate the capture efficiency of the wheel, age-1 hatchery smolts from Mactaquac Biodiversity Facility were released upstream of the smolt wheel on two separate occasions during the experiment. Hourly water temperature readings were recorded using a Vemco[1] minilog installed in the main stem of the Tobique River at the Arthurette Bridge (Fig. 10). Environment Canada collected discharge data at a gauging station located in Riley Brook (Fig. 10). Discharge is affected by NB Power water storage facilities on four tributaries upriver of the Riley Brook gauging station (Carr 2001).

In addition to the smolt wheel, a fine mesh trapnet was set in the Tobique Headpond less than 1 km upstream of the Tobique Narrows Dam (Fig. 10) for recapture and capture of respective marked and unmarked smolts. Smolts captured at this trapnet were to provide the basis for estimating the total smolts leaving the river and as well, run timing of the migration to Tobique Narrows Dam.

2001

Two rotary screw traps were installed in the main stem of the Tobique River just downstream of the confluence of Three Brooks tributary (Fig. 10). One rotary screw trap was constructed by E.G. Solutions (1.52 meters in diameter) and the second by Key Mill Construction Ltd. of Ladysmith, BC (1.82 meters in diameter) as described in detail in Chaput and Jones (2004). On May 10, after flows decreased enough, 3.65 meter wings (deflectors) were used on the American designed wheel. The wheels were continuously operated and checked once daily, usually in the morning. To estimate the efficiency of the wheels, a proportion of the captured smolts were periodically released five kilometers upstream at Plaster Rock. Herein, these smolts will be referred to as "recycled" releases.

Similar to 2000, a fine mesh trapnet was set in the Tobique Headpond just upstream of the Tobique Narrows Dam for recapture and capture of respective marked and unmarked smolts.

Also in 2001, the intake gatewells at the Beechwood Power Generating Station were sampled for immigrating smolts two or three times a week during the spring migration period. A square nylon mesh net was used to capture smolts in the intake gatewells. Generally the

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[1] Vemco Limited, Shad Bay, NS

net was left fishing for approximately 15 minutes in selected gatewells. All captured smolts were identified for origin (hatchery-origin fish were adipose clipped), measured for fork length and weight and approximately 20% of the smolts were scale sampled for later age determination. Weight data was not recorded during the first two days of sampling. The majority of smolts were released downstream of Beechwood Dam. Some of the captured smolts were transported to the Mactaquac Biodiversity Facility and were later tagged with acoustic pingers as part of a smolt tracking project. This research project, led by Dr. Gilles Lacroix, DFO, tracked smolt movements in the lower Saint John River and in the Bay of Fundy. Nineteen wild smolts captured at Beechwood Dam and 20 Mactaquac-reared smolts were tagged with pingers and released downstream of Mactaquac Dam.

2002

Smolts were captured, marked and released from three rotary screw traps (two 1.82 meter diameter and one 1.52 meter diameter) just downstream of the confluence of Three Brooks tributary in the main stem of the Tobique River. All captured smolts were identified for origin (hatchery-origin fish were adipose clipped), measured for fork length and weight and approximately 20% of the smolts were scale sampled for later age determination. To estimate the efficiency of the three wheels, the majority of the captured smolts were released just downstream of the confluence of Burntland Brook (near Diamond Island), approximately 15km upstream of the smolt wheels (Fig. 10). In addition to these "recycled" smolt releases, 500 garment tagged hatchery smolts reared at the Mactaquac Biodiversity Facility were released weekly throughout the smolt migration period. A different colored garment tag was used for each week. This provided an additional capture efficiency estimate for the three smolt wheels.

Again in 2002 the intake gatewells at the Beechwood Power Generating Station were sampled twice weekly for emigrating smolts using the square nylon mesh net. At least four of the nine gatewells were sampled on each sampling day.

2003

During the spring of 2003 two rotary screw traps were installed and operated in the main stem of the Tobique River just downstream of the confluence of Three Brooks tributary. As in previous years, captured smolts were identified for origin (hatchery-origin fish were adipose clipped), measured for fork length and weight and approximately 20% of the smolts were scale sampled for later age determination. As in the previous spring, wild smolts were "recycled" upriver to the confluence of Burntland Brook and garment tagged hatchery smolts were released weekly throughout the smolt migration period

The intake gatewells at the Beechwood Power Generating Station were again sampled but not as routinely as the previous spring, using the traditional square nylon mesh net as well as a newly designed mini-trapnet. The mini-trapnet, constructed from ABS plumbing pipe and nylon mesh, was generally set 24 hours in advance of fishing.

Results

2000

The smolt wheel was operational on all days between May 3 and June 1, 2000. No fish were captured during the last seven days of operation (Fig. 11). A total of 78 smolts (90% wild) were captured over the one month period (Table 9). None of the hatchery smolts captured were from the spring releases but were from fall fingerling parr released the previous two years. Sixty-two percent of the total smolt catch occurred from May 7 - 10 when daily water temperatures averaged 10°C. A total of 54 age-1 parr were also captured throughout the sampling period.

The trapnet was operated from May 15 until May 31 and captured six wild and 16 hatchery smolts. Based on size (mean length 19.6 cm) and coloration, all hatchery smolts were from the spring releases. Two loads of approximately 1,000 age-1 hatchery smolts from the Mactaquac Biodiversity Facility were released on May 8 and 16. Catches of hatchery smolts peaked on May 23rd, at least six days after being released at the mouth of the Odell tributary (Fig. 11). The paucity of recaptures prevented estimation of run size in 2000.

2001

The smolt wheels were installed and operational on all days between May 1 and May 30. A total of 262 unmarked smolts (63% wild) (Table 9) and 677 age-1 wild parr were captured. During the last eight days of operation, only five smolts were captured. Sixty-three percent of the wild smolt catch occurred between May 11 - 16, approximately one week later than 2000 (Fig. 11). Peak smolt catches corresponded with mean water temperatures greater than 10°C on May 12 - 13, as well as an increase in flows from May 15 - 16 (Fig. 12). Between May 11 and May 23, 149 smolts were "recycled" upstream and released near Plaster Rock. Eleven of those were recaptured one day later at the smolt wheels, inferring a 7.4% capture efficiency. The estimated smolt run upstream of Three Brooks is estimated at 3,560 (95% C.I.; 2,280 - 7,960) (Fig. 13), apportioned into 2,240 wild and 1,320 hatchery smolts.

The trapnet was operated from May 5 until May 30 and captured 27 wild and eight hatchery smolts. The trapnet captured only two (less than 1%) of the 262 marked smolts. Too few smolts were captured in the trapnet to allow an estimate of population using its data.

Sampling at Beechwood Dam intake gatewells started on May 22 and concluded on June 11. During eight days of sampling 632 (93% wild) smolts were captured, including seven smolt recaptures originally tagged at Three Brooks. These smolts were recaptured on average 15 days (Min = 9 days, Max = 20 days) after being tagged and released. One additional smolt recapture was originally tagged as a presmolt in the fall of 2000. Since the period of sampling at Beechwood did not comprise the entire smolt run, a population estimate was not attempted using this data.

As part of an autumn presmolt study carried out by DFO and Tobique Salmon Protective Association in 2001, a total of 1,496 wild presmolts were captured in two smolt wheels operated in the main stem of the Tobique River near Plaster Rock and subsequently tagged and released (Jones and Fitzherbert 2002). One-hundred and eighty-nine (12.6%) were recaptured and included in the total catch of 1,319 wild presmolts captured in two smolt wheels operated at the Three Brooks site. With the addition of the 600 presmolts removed for a captive-rearing adult program, the estimated fall migration of wild presmolts to November 13 downstream of the Three Brooks site was 11,000 (95% C.I.; 9,600 – 12,600) during the fall of 2001 (Jones and Fitzherbert 2002). This emigration generally occurs from early September to mid November but peaks during the last week of October and first week in November (Jones and Fitzherbert 2002).

2002

The three smolt wheels were installed on April 23 and were operational until June 5. A total of 496 unmarked smolts (64% wild) were captured during the seven weeks of operation (Table 9). Only seven smolts were captured during the last week. Twenty-five percent of the wild smolt catch occurred between May 7 - 9, approximately one week earlier than 2001 but similar to 2000. These peak smolt catches correspond with an increase in mean daily discharge (Fig. 12) while the mean daily water temperatures were between 7 - 8°C during those three days (Fig. 11). In addition, 349 age-1+ parr were captured during the sampling period.

Four hundred and twenty-two smolts were tagged with numerical streamer tags and released 15 kilometers upstream of the smolt wheels. Twenty-two of the recycled smolts were recaptured at the smolt wheels thereby resulting in an overall efficiency of 5.2%. The smolt run upstream of Three Brooks was estimated at 9,500 (95% C.I.; 6,800 - 15,900) which was proportioned into 6,100 wild and 3,400 hatchery smolts (Fig. 13). These hatchery smolts were adipose clipped and had been released as fall fingerling parr in 2000 and 2001. This 2002 wild spring smolt estimate, combined with the 2001 wild fall presmolt estimate suggests that a significant proportion (64%, not accounting for over winter mortality) of the wild Tobique River smolt output emigrates during the fall period.

A total of 2,357 garment tagged hatchery smolts (mean length = 17.9 cm) were released at the same location as the recycled smolts. Ninety-seven or 4.1% of the garment tagged smolts were subsequently recaptured in one of the three smolt wheels and usually one-day after being released, a slightly lower efficiency but not significantly different (chi-square test; d.f.=1, x^2=1.053; P>0.05) than the recycled smolts. Using the garment tagged hatchery smolts, the spring smolt run was estimated at 12,100 (95% C.I.; 10,200 - 14,700) or 7,800 wild and 4,300 hatchery smolts.

Sampling at the Beechwood Dam intake gatewells in 2002 started on April 30 and concluded on June 20. Sampling on 16 days yielded a total of 333 (87% wild) smolts (Table 9, Fig. 11). This included four smolt recaptures originally tagged upstream of the dam in 2002. These four streamer tagged smolts represented less than 1% of the tagged fish available for recapture (n=422) and were recaptured on average 21 days (8,14, 27 and 35 days) after being released upstream of Plaster Rock. Also included in the catch were 32 garment tagged hatchery smolts that were released on the Tobique. Only one garment tagged smolt was recaptured from the first three weekly releases in late April/early May (i.e. one in 1,500 garment tagged). The majority of the recaptures were from the last weekly release on May 22 (n=361). Twenty-three of the 361 tagged smolts (6.4%) were recaptured, including two smolts that were caught almost one month after they had been released upstream.

During the fall of 2002, wild and hatchery presmolts from the Tobique River were captured for conservation purposes (captive-rearing adult program) so run size estimates were not calculated during the fall of 2002.

2003

High spring flows prevented installation of two smolt wheels until May 5, 2003 (Fig. 12). The smolt wheels were operational until May 28. During this period the wheels were checked on a daily basis and captured a total of 119 and 50 wild and hatchery unmarked smolts, respectively (Table 9). Only seven smolts were captured during the last week of operation. Sixty-two percent of the wild smolt catch occurred between May 13 - 19 approximately one week later than 2002, but similar to 2001. Water temperatures remained cooler longer in 2003, than in the previous three springs and appeared to delay the smolt migration (Fig. 11). Mean daily water temperatures in the main stem of the Tobique did not exceed 8°C until May 17 in 2003, compared to May 5, May 4, and May 10 during the 2000, 2001, and 2002 migration periods, respectively. Also captured during the sampling period were 895 age-1 parr.

Clear numerical streamer tags were applied to 139 smolts prior to release upstream of the smolt wheels near Burntland Brook. The estimated capture efficiency of the two wheels in 2003, based on the recapture of six of the recycled smolts, was 4.3%. The smolt run upstream of Three Brooks was estimated at 3,900 (95% C.I.; 2,250 - 12,755) or 2,770

wild and 1,130 hatchery smolts (Fig. 13), equivalent to 0.03 wild smolts per 100 m^2 - a 55% reduction from the 2002 spring estimate. The hatchery smolt originated from fall parr releases. Since run size estimates were not calculated during the fall of 2002 the proportion of the total wild Tobique River smolt output represented by the spring smolt estimate is unknown.

A total of 1,483 garment tagged hatchery smolts (mean length = 15.7 cm; mean weight = 38.5 grams) were released at the same location as the recycled smolts. Twenty-one or 1.4% of the garment tagged smolts were subsequently recaptured at the smolt wheels and generally one day after being released. Using a capture efficiency based on garment tagged hatchery smolts, the spring smolt run was estimated at 11,900 (95% C.I.; 8,600 - 19,900) or 8,450 wild and 3,450 hatchery smolts.

Sampling at the Beechwood Dam intake gatewells started on May 15 and continued until June 9, 2003. At least four of nine intake gatewells were sampled on 10 different occasions over the four week period. A total of 528 smolts, including six smolts with streamer tags and 18 garment tagged smolts originally tagged and released in the Tobique River, were captured (Table 9, Fig. 11). As in the previous two years, greater than 85% were of wild origin.

The six streamer tagged smolts were recaptured on average 10 days (min = 5 days; max = 17 days) after being released upstream near Burntland Brook. These six recaptured smolts represented 4.3% of the streamer tagged smolts available for recapture. Of the 18 garment tagged recaps, six were green and 12 were red, representing 1.2 and 2.4% of the May 12 and May 20 releases, respectively. None of the smolts released on May 7 were recaptured during the sampling of the intake gatewells at Beechwood.

Unlike in 2002, the recapture rates for the "recycled" wild/hatchery (fall fingerling released) smolts was significantly higher (chi-square test; d.f.=1, x^2=6.532; P<0.05) than that determined from the garment tagged hatchery smolts in 2003; 4.3% and 1.4%, respectively. The lower recapture rate of spring released hatchery smolts (both untagged and tagged), at least when compared to wild or fall fingerling released hatchery smolts, has also been observed on other rivers (Fig. 14). For this reason the smolt production estimates determined from the recycled wild/hatchery smolts were preferred over the estimates generated from the garment tagged hatchery smolts.

Biological Characteristics

Scale samples collected from the wild smolts sampled at the smolt wheels on the Tobique River in 2003 were predominately (61%) age-3 with a mean length of 15.6 cm (n=11) although sample size was small due to the low catches (Fig. 15). Age-2 (n=7) wild smolts averaged 13.7 cm while the combined mean length of all wild smolts was 14.6 cm (n=88). The mean length of wild smolts sampled in 2003 was similar to those sampled in 2001 (n=212) and 2000 (n=76) but larger than 2002 smolts (n=334). The size of the wild smolts sampled on the Tobique River since 2000 is very similar to those sampled on the Nashwaak River (Fig. 15). All of the hatchery (adipose clipped) smolts sampled in 2003 were age-1, therefore released as 0+ parr during the fall of 2002, and averaged 13.4 cm in fork length. Mean length of all hatchery smolts was 13.2 cm.

Outlook

Projected returns, based on the average returns of the previous five years, for populations originating upriver of Mactaquac Dam on the Saint John River in 2004 are 2,340 (90% C.I.; 960 - 3,720) 1SW and 940 (90% C.I.; 180 – 1,890) MSW salmon. The probabilities of

attaining the conservation requirement of 4,900 for both 1SW and MSW salmon are near zero for both forecasts. Unless the current situation changes and an increase in marine survival is realized, the prospect for an increased 1SW salmon return in 2004 is poor. Based on escapement in 1999 and 2000, parr densities (2002), and Tobique smolt production (2003) wild 1SW salmon returns for 2004 will only increase if marine survival improves from recent years. Because virtually no unfed fry were released in 2001 and smolt releases in 2003 were considerably reduced (-36%), no increase in hatchery 1SW salmon returns are anticipated for 2004. In recent years, the return rates of hatchery smolts to-1SW and to-2SW salmon have followed similar patterns (Fig. 4). Therefore, the decrease in the smolt-to-1SW salmon return rate observed in 2003 suggests fewer hatchery 2SW returns in 2004.

Management Considerations

For the Saint John River populations upstream of Mactaquac Dam, egg depositions have been less than 50% of requirement for nine of the last ten years. There is a near zero probability that MSW returns will be adequate to meet the conservation requirement in 2004. There is also a near-zero probability of attaining the 1SW salmon conservation requirement of 4,900 fish.

In an effort to maintain existing genetic integrity for potential recovery of the upstream populations, a captive-reared broodstock program was initiated in 2001 at Mactaquac Biodiversity Facility. The first adult releases from this program occurred in 2003. The first significant contribution to egg depositions is expected to occur in 2004 with the release of approximately 1,000 large salmon. The first adult returns from the 2004 releases are not expected until 2008.

Revisions to Mactaquac Fish Culture Program

The Mactaquac Biodiversity Facility (formerly Fish Culture Station) has been involved in the mitigation of salmon lost to hydroelectric projects on the Saint John River. Since construction, the facility has emphasized smolt production as a method of embellishing river returns and access to the resource by fishers. Rapidly diminishing returns of wild and hatchery salmon to Mactaquac and failure to meet the conservation requirement, resulted in closures of in-river fisheries. Recent thinking has been that the program at the Mactaquac Biodiversity Facility could be re-focused to the singular objective of conserving and restoring a declining resource. Thus, discussion within DFO and the Hatchery Subcommittee of the Saint John River Management Advisory Committee, (SJRMAC) resulted in a proposal to replace a large portion of the traditional smolt production with production of age-0+ fall parr and captive rearing to broodstock of mostly wild-origin juvenile salmon for release and natural spawning upriver of Mactaquac.

Concerns regarding smolt production as an effective method of conservation included: a) increasing proportion of identified hatchery fish among total returns; b) increasing possibility that "wild"-appearing returns were F2 or F3 hatchery; c) the increasing proportion of wild MSW returns required to sustain hatchery smolt production; d) the loss of those wild broodstock from natural spawning; e) the high proportion of hatchery-smolt origin returns that are male 1SW fish with limited potential to augment the population; f) the possibility that Mactaquac-origin returns might be less capable of selecting viable spawning areas than homing wild fish and, g) the possibility that artificial mating of broodstock may produce smolts that are less fit than their wild counterparts produced from natural mate selection.

The possibility for success in the captive rearing of broodstock is evident from the recent successes in captive rearing of inner Bay of Fundy wild parr to broodstock at Mactaquac (O'Neil et al. 2004) and the natural spawning of sea cage-reared F1 broodstock in the Big Salmon River (Bruce 1995). Such a plan for the Saint John River upstream of Mactaquac will circumvent the current high marine mortality and should yield significant numbers of adults for release and natural spawning in their tributary of origin. The program was initiated in the fall of 2001 with the transfer to Mactaquac of 2,529 wild and hatchery (at least one year in natural environment) juvenile salmon captured in smolt wheels (Table 10) from the Tobique River. It is expected to "cost" as few as 16 - 32 adult returns and yield an estimated 1,400 adults for release and spawning. Benefits include: potentially more than doubling the natural egg deposition upriver of Mactaquac, increased utilization of proven freshwater habitat, natural selection on subsequent production and the additional escapement of 200 wild fish that would otherwise have been used as hatchery broodstock. A few hundred captive-reared broodstock will be retained and bred for the production, rearing and release of age-0+ fall parr and limited numbers of smolts for research purposes.

Depending on its assessed success, the program would eventually utilize upwards of 30 of the 40 large ponds that normally produced smolts. Five ponds are required per stock unit to carry fish from pre-smolts through maturity as either 1SW or 2SW mature fish. The 2,529 Tobique juvenile salmon collected in 2001 constitute three units utilizing 15 ponds. The inclusion of additional tributaries will depend on successes and continued consultation within the Hatchery Subcommittee of the SJRMAC.

Smolt production at Mactaquac is being scaled back from approximately 300,000+ to 40,000 - 50,000 smolts available for various assessment activities. Thus, returns from hatchery smolt production will diminish over the next several years. Adult returns from the juveniles collected in 2001, currently being reared to adults for release from Mactaquac and spawning in the Tobique River, will not be evident until 2007 - 2009. With the current diminishing returns of wild salmon, it is then very likely that total returns to Mactaquac will continue to decline through at least 2007 (Fig. 5; Fig. 8; Fig. 9).

NASHWAAK RIVER

With a drainage area of about 1,700 km^2, the Nashwaak River flows approximately 110 km in an easterly and southerly direction from Nashwaak Lake on the New Brunswick York/Carleton County line to its confluence with the Saint John River in Fredericton North (Figs. 1 and 16). The river is the largest single salmon-producing tributary of the Saint John downstream of Mactaquac Dam. The salmon production area of the Nashwaak River has been estimated from orthophoto measurements (Amiro 1993) at 5.69 million m^2 (gradient > 0.12%) or 28.5% of the total salmon production area downstream of Mactaquac Dam (Marshall et al. 1997). A salmon counting fence 23 km upstream from the confluence with the Saint John (Fig. 16) was operated by DFO in 1972, 1973 and 1975 (Francis and Gallop 1979), and by DFO in cooperation with Aboriginal peoples from 1993 - 2003. In 2003, the fence was jointly operated by Kingsclear and Oromocto First Nations.

Returns

Methods

All fish captured at the counting fence were counted, measured for fork length, classified as hatchery or wild on the basis of fin deformities and/or presence of adipose fin, and marked with a hole punch of the caudal (hatchery fish) or adipose (wild fish) fin. All adipose clipped salmon (hatchery fish) were scale sampled along with every second wild fish to determine the

age composition of the adult returns. Exceptions were made to the sampling routine when water temperatures at the fence exceeded 22°C. During these trap checks fish were classified as 1SW or MSW salmon based on size, but no additional sampling occurred. As a result five 1SW and three MSW salmon were released upriver between July 17 and 21 unmarked. Holding pools upstream of the fence were seined in early September so that mark -recapture procedures (Gazey and Staley, 1986) could be used to estimate the number of fish that may have bypassed the fence either before installation or during operation.

Results

Unadjusted counts at the Nashwaak fence during the June 5 - October 26 operating dates numbered 186 1SW and 87 MSW salmon. The start date was the second earliest since operation resumed in 1993. The finish date was the day on which extremely high water levels topped the fence - the fourth occasion in 2003. A summary of start and finish dates, periods or dates in which the fence was not completely fishing due to high water and the assessment technique used to assess total returns are summarized in Table 11.

After scale analysis, 1SW and MSW salmon components were slightly revised to 188 1SW and 85 MSW salmon (Table 2). The final hatchery counts were seven 1SW and three MSW salmon and represented about 4% of both the total 1SW and MSW salmon counts. Similar to the previous four years, the majority of the 1SW salmon (60% in 2003) passed through the fence during the month of July (Fig. 17). The greater part (42%) of the MSW salmon run was counted during the first two weeks of October. Generally very few 1SW and MSW salmon were counted during the month of August and the first two or three weeks of September (Fig. 17). Scale samples revealed that sea-ages of the wild fish in 2003 were 72% virgin 1SW fish, 25% virgin 2SW fish and 3% previous spawners. The proportion of 1SW and 2SW salmon returns is similar to values observed in four of the last five years; the exception being 2001 (Fig. 18). Since 2000, the age (sea) structure of Nashwaak River wild salmon returns has been very similar to those wild salmon returning to Mactaquac (Fig. 18). Previous spawners from 1993 - 2002 averaged about 25% of the returning Nashwaak River MSW salmon. In 2003 only 9% of the MSW returns were previous spawners, the second lowest percentage observed since 1993 (Fig. 18). Very few virgin 3SW salmon are observed in either population.

Seining and snorkel observations in 10 pools (Fig. 16) upriver of the counting fence (Sterling Wharf, Mouth of Tay River, Colter's, Cross Creek, Nashwaak Bridge, Little Basin, Buttment, Williamson's Camp, Burnt Camp, Sister's) on September 18 - 19 resulted in the capture or visual observation of 12 small and 17 large salmon. Seven of the 29 fish were observed by multiple divers in the following pools; Buttment (3), Little Basin (1) and Mouth of Tay River (3). Fifteen (seven 1SW and eight MSW salmon) were previously adipose punched (marked) at the counting fence.

To estimate the total returns through October 15, 2003, it was necessary to determine the number of salmon moving upriver prior to fence installation and during a three day period in August (Table 11) when the fence was not fishing due to high water. Mark-recapture data were incorporated in a Bayesian estimate procedure described by Gazey and Staley (1986) to determine the most probable estimate (the mode) of population size and a binomial distribution was assumed for random sampling error. This analysis indicates a population of 226 (95%C.I.; 174 - 380) 1SW and 58 (95%C.I.; 44 - 97) MSW salmon moved past the fence during 2003 as of September 19 (Fig. 19). The sum of these estimates and adjusted fence counts after September 19 yielded a return estimate of 297 1SW and 113 MSW salmon (Table 12). The malfunction of the fence during the high water flows that occurred after October 15 (Fig. 17) suggests that additional fish may have been missed. Adequate fall discharge prior to October 15 and few (2.5%) wild returning adults to Mactaquac after October 15 suggest however that the estimates likely represent greater than 95% of the returns.

Estimated wild returns in 2003 totalled 287 1SW and 109 MSW fish (Fig. 20). One-sea-winter returns were down slightly from 2002, were the second lowest estimated since 1993, and were only 39% of the 10-year mean. Multi-sea-winter returns increased 49% from 2002, were only 34% of the 10-year mean, and were also the second lowest estimated total since fence operation resumed in 1993. The return rate of the 2002 wild smolt class as 1SW salmon in 2003 was 0.0191 - the median value of the calculated return rates since wild smolt assessments were initiated in 1998 (Table 13). The return rate of the wild smolt class of 2001 as 2SW salmon in 2003 was 0.0090 – the highest return rate observed since 2000 and more than three times greater than the rate in 2002 (Table 13). Estimated hatchery returns in 2003 totalled 10 1SW and 4 MSW fish. The return rate of 2,148 garment tagged 1-year smolts released in 2002 (reared at the Mactaquac Biodiversity Facility) as 1SW salmon in 2003 was 0.00186; about ten fold lower than the wild smolt return rate.

As in previous years, no account has been made of salmon by-catch in the Saint John Harbour that may have been destined for the Nashwaak River.

Removals

One 1SW and two MSW salmon mortalities were recovered between July 6 and July 15 on the upstream side of the fence. *Aeromonas salmonicida*, the causative agent of furunculosis, was isolated from one of the two samples. One additional grilse was dead inside the trap on October 23 and was a suspected casualty of high water. DFO fishery officers reported no illegal activities targeting salmon destined for or within the Nashwaak watershed. Therefore, no corrections were made for illegal removals. Between June 26 and July 25, 15 1SW salmon and two MSW salmon were removed from the fence trap and transported to Mactaquac Biodiversity Facility for restoration initiatives of the Nashwaak Watershed Association. Unfortunately, all 17 fish died as a result of an accident at the Biodiversity Facility.

Conservation Requirements

Salmon production area upstream of the fence is estimated to be 5.35 million m^2 and the conservation requirement is 12.8 million eggs (Marshall et al. 1997). Biological characteristics of salmon caught at the fence from 1993 - 1996, indicates that 2,040 MSW salmon and an equal number of 1SW salmon would be required to meet the conservation requirement (Marshall et al. 1997). The MSW salmon requirement was calculated on the basis of having a male to female ratio of 1:1. Egg deposition and spawners in 2003 were estimated on the basis of length, external sexing and interpretation of age from scales collected from fish passing through the fence.

Escapement

Spawners upstream of the fence were estimated to be 280 1SW and 109 MSW salmon (Table 12). Sea-age, origin, female composition and mean length for spawners upstream of the fence are summarized below:

	1SW salmon		MSW salmon	
Biological characteristics	Wild	Hatchery	Wild	Hatchery
Number	270	10	105	4
Proportion female	0.273	0.286	0.900	0.667
Mean length female (cm)	58.1	60.6	77.5	75.4

Numbers of 1SW and MSW spawners were 14% and 5% of the conservation requirements, respectively. The number of 1SW spawners decreased slightly from 2002 while MSW spawners increased by 58% from the record low spawners in 2002. Egg deposition was estimated at about 950,000 (0.17 eggs m^{-2} or 7% of the egg requirement), second lowest since fence operation resumed in 1993 (Table 12). One-sea-winter females contributed 28% of the total estimated egg deposition, compared to 46% in 2002.

Parr Densities

Methods

Densities of juvenile salmon have been monitored annually at seven sites on the Nashwaak River since 1981 (Fig. 16). Densities prior to 1981 along with site characteristics and locations were reported by Francis (1980). Densities during the 1980's have been adjusted to account for the expanded sites that were initiated in 1990 and 1991 (Marshall et al. 2000). Densities (number of fish per 100 m^2 of habitat) at these expanded sites were for the most part derived from mark-recapture techniques. Total number of age-1+ and older parr were estimated using the adjusted Petersen method (Ricker 1975). The number of parr by age was determined from stratified sampling of large parr in 0.5 cm intervals. Generally a maximum of two parr were scale sampled for each length interval. The number of age-0+ parr or fry for a site was determined by applying the calculated capture efficiency of the crew from the marking pass, to the number of fry captured during the marking pass. In 2003, in addition to the seven sites continuously done since 1981, another 11 sites were added to the Nashwaak River juvenile surveys (Table 14; Fig. 16).

In 2003, parr densities were calculated by applying the mean capture probability (1996-2003 data) to the marking pass catches for sites in which no parr were either marked or recaptured or if only the marking pass was completed. Prior to 2003, if zero parr were marked or recaptured then the average capture efficiency for that year was used to determine the density of fry and/or parr for that particular site (see page 6). For this document no adjustments were made to the pre-2003 site densities using the 1996-2003 mean capture probability.

With the exception of the 2003 analysis (Table 8; Table 13), the densities presented in this document are for wild (or adipose fin present) parr only. For the most part, prior to 1998 all fall fingerling and unfed fry were released unmarked and suspected hatchery-origin parr captured during electrofishing surveys were determined by observations made by field staff of fin erosion or condition (Appendix *iii*). Since 1996, most fall fingerlings released were adipose clipped and there were fewer unfed fry releases, thereby making the identification of wild parr easier and more accurate.

Results

Analysis of the historical mark-recapture data (which included Nashwaak data) using the empirical Bayes method determined that the mean probability of capture was 34.7% (5^{th} and 95^{th} percentiles 20.0 and 53.1%). This mean probability of capture was used for two of the seven sites (historical) done annually since 1981 and for eight of the 11 additional sites electrofished on the Nashwaak in 2003 (Table 14).

Mean density of wild fry (age-0+ parr) at the seven historical sites (one downstream and six upstream of the counting fence) was 4.2 fry per 100 m^2 and ranged from 0.7 to 5.5 fry per 100 m^2. This was the second lowest average density estimated since 1981 and consistent with the low egg depositions estimated in 2002 (Table 12; Fig. 21). Since 1993, mean densities at the seven sites have been below the "Elson norm", fluctuating around 10

fry per 100 m2 (Fig. 21). Including data from the 11 sites added in 2003 raised the mean density to 5.8 fry per 100 m2 and ranged from 0.0 to 17.4 fry per 100 m2 (Table 14).

Mean density of age-1+ and older wild parr at the seven historical sites was 5.4 fish per 100 m2 (ranged from 0.0 to 12.8) and increased to 6.5 fish per 100 m2 (ranged from 0.0 to 12.9) when the 11 new sites were included in the analysis. These values were similar to the densities observed in the last decade and are well below Elson's (1967) "normal index" of 38 small and large parr per 100 m2 (Fig. 21). The high mean fry density (17.4 per 100 m2) observed in 2002 did not result in an increased parr density in 2003.

Smolt Assessment

A collaborative project between DFO and the Nashwaak Watershed Association Inc. (NWAI) to estimate the wild smolt production of the Nashwaak River has been ongoing since 1998. The smolt production estimates are valuable in examining recent declines in salmon populations for the following reasons: 1) they contribute to the development of current expectations for and limitations to salmon production on the Nashwaak River and probably other tributaries of the Saint John River downriver of Mactaquac Dam, 2) they provide a marine survival estimate examined through smolt-to-adult return rates where adult returns are derived from data collected at the Nashwaak River counting fence, and 3) they provide a basis for evaluating freshwater production which can be examined through parr-to-smolt and egg-to-smolt survival rates when estimates of juvenile densities of salmon and eggs deposition are available.

Methods

Mark-recapture methods were used to estimate the number of smolt emigrating from the Nashwaak River. As described in Marshall et al. (1999b), smolts were captured, marked and released at a portable counting fence on the Tay River from 1998 to 2001. The Tay River, one of the largest tributaries on the Nashwaak River, represents approximately 8% of the parr habitat upstream of Durham Bridge. Smolt were recaptured using a 1.52 meter diameter rotary screw trap (constructed by E.G. Solutions), that has been installed annually (1998 - 2003) in the main stem of the Nashwaak River just downstream of Durham Bridge (Chaput and Jones 2004). In 2001, in addition to the counting fence, a proportion of the unmarked smolts captured at the smolt wheel were marked and released ("recycled") upstream of the smolt wheel. Marked smolts captured and released at the counting fence and those "recycled" upriver of the smolt wheel resulted in similar estimates of smolt wheel capture efficiency (Fig. 14).

As in previous years, the smolt wheel was installed and operated in the main stem of the Nashwaak River just downstream of Durham Bridge in 2003. The wheel was checked once daily except during the first and last weeks of operation when it was checked for six of the seven days (it was not checked on either the Saturday or Sunday). All smolts were identified for origin (wild or hatchery), one in five wild unmarked smolts was measured to fork length, weighed, scale sampled and marked with alcian blue dye (lower caudal) and released 500 meters downstream of the wheel. In general, the remaining unmarked smolts were marked with numbered clear streamer tags and released at two locations upstream (Fig. 16). Detailed sampling occurred on all hatchery smolts released as fall fingerlings.

Similar to 2002 and in addition to these "recycled" smolt releases, between 300 - 500 garment tagged hatchery smolts, reared at the Mactaquac Biodiversity Facility, were released weekly throughout the smolt migration period. A different colored tag was used for each week. This provided an additional estimate of smolt wheel capture efficiencies. Hourly water temperature readings were recorded using a minilog installed in the main stem of the

Nashwaak River at the adult counting fence location (500 meters downstream of the smolt wheel). Environment Canada collected discharge data at a gauging station located near Durham Bridge.

Results

The rotary screw trap was installed on April 28, but high water levels prevented setting the wheel until May 5, 2003. A total of 780 untagged smolts (682 wild; 26 hatchery-fall fingerling; 72 hatchery-spring smolt) were captured prior to the removal of the smolt wheel on June 6. Only five wild smolts were captured during the last week of operation. The highest wild smolt catch occurred on May 21, the fifth consecutive day in which mean daily water temperatures exceeded 10°C (Fig. 22). The cooler spring water temperatures appeared to delay the smolt migration in 2003 compared to the previous five years when at least 50% of the cumulative smolt catch had occurred by May 9 (Fig. 22). Discharge, unlike water temperatures, does not appear to have an effect on the peak smolt movements (Fig. 23).

Four hundred and forty-seven wild smolts were tagged with clear numbered streamer tags and released at two locations upstream of the smolt wheel: Nashwaak Bridge and at the mouth of the Tay River (Fig. 16). Thirty-four (7.6%) of the recycled smolts were recaptured at the smolt wheel. This mark-recapture data generated a most probable Bayesian estimate of 9,000 (95% C.I.; 6,800 - 13,200) wild smolts emigrating from the Nashwaak River in 2003 (Table 13; Fig. 24). The total number of wild smolts decreased 40% from 2002 (DFO 2003a), was only 50% of the five-year mean, and was the lowest estimated total since smolt assessment commenced in 1998 (Table 13). Using the capture efficiency of 7.6% for the wild smolts, an additional 350 hatchery smolts that had been released as fall fingerlings in 2001 and 2002 were estimated to have emigrated in 2003 along with the 6,700 spring released age-1 smolts.

A total of 1,780 garment tagged hatchery smolts (mean length=17.9 cm) were released on four occasions (May 6, 12, 20, and 26) upriver of the smolt wheel at Nashwaak Bridge (Appendix *iii*). A different colored garment tag was used for each release. Only 26 or 1.5% of the garment tagged smolts were subsequently recaptured in the smolt wheel and generally one or two days after being released. As in 2002, the smolt wheel efficiency based on the garment tagged smolt was significantly lower than that determined using the recycled wild smolt in both years. Seventy-two of the 4,918 unmarked spring hatchery smolts released on May 28 were captured in the smolt wheel, an identical proportion to the garment tagged smolts (1.5%). Smolt assessments from the Tobique, Nashwaak, and Big Salmon rivers (Gibson et al. 2004) have indicated that smolt wheel capture efficiencies determined from spring released hatchery smolts are consistently lower than those determined from wild and fall fingerling released smolts and if used would have over estimated the wild smolt populations (Fig. 14).

Also in 2003, thirty wild smolts were acoustically tagged as part of a collaborative research project between DFO and the NWAI which was partially funded by NB Wildlife Trust Fund. This project examined wild smolt survival and the migration patterns to the mouth of the Saint John River and was a follow up to a similar project conducted in 2002.

Biological Characteristics

The average fork length of all the wild smolts sampled in 2003 was 15.1 cm (n=143). This value was the second largest and is similar to the mean length of the wild smolts in 2000 (Fig. 15). Ages of wild smolts were predominately age-2 (75%) with a mean length of 14.7 cm. The remaining wild smolts were age-3 and averaged 16.1 cm. Mean fork length values by age were similar to those observed from wild smolts sampled since 1998 (Fig. 15).

Outlook

Predicted returns to the Nashwaak River in 2004 using the five year average are 410 1SW fish (90% C.I.; 140 - 690). There is a near zero probability that the 1SW requirement of 2,040 fish will be met. The forecast of MSW returns is 190 fish (90% C.I.; 50 - 330) and the probability that the conservation requirement of 2,040 MSW fish will be attained is also near zero. Appling the range (minimum and maximum) of smolt-to-1SW return rates observed since 1999 to the 2003 wild smolt estimate indicates the predicted 1SW returns to the Nashwaak in 2004 could be between 140 and 280 fish. This method has proven to be a more reliable forecast in comparison to the five year mean. The predicted 2SW salmon returns in 2004, from the 2002 smolt class, range from 40 to 130 fish using observed the smolt-to-2SW return rates. Declining numbers of adult returns and subsequent spawners, particularly MSW salmon, and low densities of parr suggest that returns will not be adequate to achieve the egg conservation requirement for several years to come.

Management Considerations

The Nashwaak River population attained only about 7% of the conservation requirement in 2003. Total egg depositions were less than 25% the conservation requirement for the last five years and have steadily declined, along with the corresponding smolt classes, since 1996. Prospects for attaining the conservation requirement in 2004 are near zero and, based on low parr densities, the prospects for increased returns for the next several years are extremely poor. Unlike 1SW fish returning to Mactaquac Dam, the Nashwaak River 1SW salmon from 1993 to 2003 have averaged 39% female and have contributed an average of 33% of the total Nashwaak River egg depositions.

MAGAGUADAVIC RIVER

Originating in Magaguadavic Lake, the Magaguadavic River flows southeasterly for 97 km to the Passamaquoddy Bay, Bay of Fundy at St. George, N.B. (Fig. 25; Martin 1984). A 13.4m-high dam and 3.7 megawatt hydroelectric station is located at the head-of-tide. Upstream passage is provided by a fishway. Assessment of the anadromous fish resources is done using a trap in the third pool from the top of the fishway. In 2003, the fishway trap was monitored for salmon from late April until early December except during the peak migration period (June 16 - July 7) for gaspereau. Salmon count data and analyses were provided by Atlantic Salmon Federation[2]. In 2003, similar to the previous year, no fish of aquaculture origin that were captured at the trap were released to the river. All salmon of suspected aquaculture origin were sacrificed for sampling of pathogens. Only one fish of suspected aquaculture origin has been knowingly released to the river since 1997. This fish was mistakenly released upriver in 2000 and potentially contributed 15.9% of the overall eggs deposited that year.

Wild returning salmon have been rapidly declining since 1992 and have averaged less than 15 fish since 1998. Aquaculture fish are escapes from aquaculture cages in the Fundy Isle area which in 2003 produced approximately 35,000 tonnes of Atlantic salmon.

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[2] Jon Carr- Atlantic Salmon Federation, PO Box 429, St. Andrews, NB, E0G 2X0

Returns

Counts of salmon in the trap numbered six wild and 23 aquaculture escapes of which seven were post smolts (Carr and Whoriskey 2004). "Wild" salmon included three 1SW and three MSW salmon which could also be the result of early life stage juvenile escapes from any of the three private hatcheries in the drainage. Counts made since 1992 when aquaculture escapes have been identified, and those in 1983 - 1985 and 1988, when escapees were largely unnoticed, are summarized in Table 2. Total counts of both wild 1SW and MSW salmon are the lowest of the record and only 40% of the mean for the last five years (Fig. 26). Counts of suspected aquaculture escapes were also the lowest of recent record.

Removals

All aquaculture fish were sacrificed for disease testing. No fish were removed for broodstock. There has been no commercial fishery since 1983, and the Aboriginal food fishery and the recreational fishery have been closed since 1998.

Conservation Requirements

The conservation requirement of 1.35 million eggs is based on an estimated 563,000 m^2 of juvenile rearing substrate (Anon 1978) and a deposition of 2.4 eggs per 100 m^2 (Elson 1975). The numbers of spawners necessary to obtain the conservation requirement are estimated at 230 MSW and 140 1SW salmon (Marshall and Cameron 1995).

Escapement

Three 1SW and three MSW fish were released upstream of the fishway (Carr and Whoriskey 2004). Biological characteristics of fish released to the river were as follows:

Biological characteristics	1SW wild	MSW wild
Number	3	3
Prop. Female	0.33	1.00
Mean length female (cm)	56.0	81.9

Using the mean length - fecundity relationship for Saint John River salmon ($eggs=430.19e^{0.03605X\text{fork length}}$) (Marshall and Penney 1983) and the estimated number of females suggest a potential egg deposition of 19,120 eggs or less than 2% of the requirement. Estimates of escapement and attainment of the conservation requirement have steadily declined since 1994 (Fig. 27).

Outlook

Wild 1SW and MSW returns to the Magaguadavic River in 2004 are projected to be no greater than the returns in 2003. There is a near zero probability of attaining the conservation requirement in 2004. Progeny of the last "disease free" wild adult returns in 1998 are being held at Mactaquac Biodiversity Facility as part of a DNA-based project in an attempt to preserve this genetic lineage. About 33,000 of these progeny were distributed to the Magaguadavic watershed in 2003 as age-0+ parr (Appendix *iv*) and are expected to contribute to adult returns in 2006 - 2007. This undertaking is a result of the action plan by the Magaguadavic Recovery Committee. Preliminary results from electrofishing surveys in 2003 indicate that the release of the 56 mature (35% female) captive reared broodstock in 2002 is unlikely to make a significant increase in adult returns in 2006 - 2007.

Management Considerations

Returns of wild salmon to the Magaguadavic River in 2003 were six fish. There is next to no chance that the conservation requirement will be met from natural production on this river in the near future.

ST. CROIX RIVER

The St. Croix River, a USA/Canada international river bordering the State of Maine and Province of New Brunswick, drains southeasterly into Passamaquoddy Bay of the Bay of Fundy. Approximately 1,619 km^2 of the drainage basin is in New Brunswick and 2,616 km^2 is in Maine (Fig. 28). Historically a significant producer of Atlantic salmon, this salmon population has succumbed to industrial development - initially cotton mills, then pulp mills, and now dams and headponds at three hydroelectric facilities. The main stem and East Branch (84 km), the Chiputneticook lakes (66 km) and Monument Brook (19 km) determine 169 km of the international boundary (Anon 1988), the fluvial portions of which comprise the bulk of the potential rearing area for Atlantic salmon.

No natural returning adult salmon have been released upriver since 1997. Future returns are dependant on hatchery programs. At least without a dramatic shift in sea survival, these conservation efforts are not expected to yield any significant number of naturalized salmon in the near future. Hatchery releases since 1981 are tabled in Appendix *v*.

Returns

Salmon were counted at the Milltown fishway which was operational from April 24 until October 23, 2003. The first salmon capture occurred on June 18 and the last on October 13 with the majority of the salmon captured in the fishway during August and September. Counts, scale samples, and external characteristic data are provided by St. Croix International Waterway Commission[3]. Interpretation of scales, by DFO staff, indicated a return of six 1SW and nine MSW hatchery salmon (Table 2). A further four 1SW and five MSW salmon were identified as fish of aquaculture origin (Fig. 29). There have been no wild returning adult salmon to Milltown fishway since 2000 (Table 2).

Removals

All 24 returning salmon were removed from the fishway trap and retained on site. Twelve salmon of hatchery origin were later transported to Mactaquac although six died before they could be artificially spawned. The other three hatchery origin MSW salmon died while being held at Milltown before transport to Mactaquac. Of nine fish presumed to be of aquaculture origin, two died and seven were lethally sampled for research.

Conservation Requirements

The conservation requirement of 7,389,000 eggs is based on an area of 3.079 million m^2 of juvenile production habitat (Anon 1988) and an average requirement of 2.4 eggs 100 m^{-2} (Elson 1975). Adult requirements have been calculated on the basis of MSW salmon having a male to female ratio of 1:1 and females producing an average of 7,200 eggs. Adult requirements therefore total 2,052 MSW salmon. A re-evaluation of adult requirements in 1993 acknowledged

[3] Lee Sochasky - St. Croix International Waterway Commission, St Stephen, NB, E3L 2Y7

the potential contribution to egg deposition by 1SW females and suggested 1,710 MSW and 680 1SW fish could potentially produce the egg requirement (Marshall and Cameron 1995).

For the sixth consecutive year, no wild or hatchery returning 1SW or MSW salmon were released upriver of Milltown Dam to spawn naturally.

Potential eggs from the hatchery returns were estimated from the length-fecundity relationship (eggs=$430.19e^{0.03605 X \text{fork length}}$) for salmon of the Saint John River (Marshall and Penney 1983). Sea-age, female composition and mean lengths for hatchery fish captured at the Milltown fishway can be summarized as follows:

Biological characteristics	1SW hatchery	MSW hatchery
Number	6	9
Prop. Female	0.17	0.89
Mean length female (cm)	55.0	74.1

Estimated eggs from the six 1SW and nine MSW hatchery salmon totalled about 53,000 eggs or less than 1% of the conservation requirement. The three males and three females spawned at Mactaquac Biodiversity Facility yielded 21,000 eggs.

Outlook

Returns to the St. Croix River in 2004 are unlikely to exceed recent values (the 1999 - 2003 mean value was 16 hatchery returns). The number of released juveniles from the hatchery programs has remained constant and low. No wild returns are anticipated in 2004. There have been no adults released upstream of Milltown since 1997 and no wild origin salmon have been captured since 2000. The first 1SW progeny from the 750 cage-reared adults released for natural spawning in 2000 are expected in 2004. A low mean density (1.0 fish/100m^2) of age-1+ and older parr from electrofishing surveys in 2002 (DFO 2003a) suggests only a few additional 1SW returns in 2004 from these releases. Under any scenario for returns in 2004, there is no probability of attaining the conservation requirement.

Management Considerations

The salmon population of the St. Croix River has declined dramatically in the last decade. There have been no wild salmon returns since 2000 and hatchery returns have been less than 30 fish since 1997. There is little to no chance that the conservation requirement will be met from natural or hatchery production on this river in the near future.

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Table 1. Estimated total (adjusted) homewater returns of wild, hatchery and aquaculture 1SW and MSW salmon destined for Mactaquac Dam on the Saint John River, N.B., 2003.

Sea-age	Components	Wild	Hatchery	Aquaculture	Total
1SW					
	Mactaquac counts[a]	443	835	3	1,281
	Mactaquac counts adjusted[b]	377	912	2	1,291
	By-catch[c]	4	9	0	13
	Totals	381	921	2	1,304
MSW					
	Mactaquac counts[a]	279	464	0	743
	Mactaquac counts adjusted[b]	234	498	1	733
	By-catch[c]	6	13	0	19
	Totals	240	511	1	752

[a]Hatchery/wild origin per external characteristics in previous assessments; fishway closed Nov. 4.

[b]Adjusted by analyses of scales from sampled fish (Marshall and Jones 1996).

[c]Estimated to be 1% of total 1SW returns and 2.5% total MSW returns and is considered to include losses to poaching.

Table 2. Counts of wild, hatchery and sea-cage (aquaculture) origin Atlantic salmon (as identified by fishway operators) trapped at fishways / fences of four rivers in southwest and central New Brunswick.

	Saint John (Mactaquac)				Nashwaak					Magaguadavic				St. Croix[c]					
	Wild		Hatchery		Wild		Hatchery		Dates of	Wild		Aquaculture		Wild		Hatchery		Aquaculture	
Year	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW	Operation	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW
1967	1,181	1,271	-	-															
1968	1,203	770	-	-															
1969	2,572	1,749	-	-															
1970	2,874	2,449	94	-															
1971	1,592	2,235	336	37															
1972	784	4,831	246	583	259	859	-	-	8/18-10/29 e										
1973	1,854	2,367	1,760	475	596	1,956	-	-	6/10-11/05 e										
1974	3,389	4,775	3,700	1,907															
1975	5,725	6,200	5,335	1,858	1,223	1,036	-	-	6/28-10/29 e										
1976	6,797	5,511	7,694	1,623															
1977	3,504	7,257	6,201	2,075															
1978	1,584	3,034	2,556	1,951															
1979	6,234	1,993	3,521	892															
1980	7,555	8,157	9,759	2,294															
1981	4,571	2,441	3,782	1,089															
1982	3,931	2,254	2,292	728										10	51	-	-		
1983	3,613	1,711	1,230	299						282	607	21	30	22	78	-	-		
1984	7,353	7,011	1,304	806						255	512			166	64	6	8		
1985	5,331	6,390	1,746	571						169	466			41	264	8	31		
1986	6,347	3,655	699	487										38	204	25	53		
1987	5,106	3,091	2,894	344										128	135	67	42		
1988	8,062	1,930	1,129	670						291	398			93	190	9	102		
1989	8,417	3,854	1,170	437										79	94	37	21		
1990	6,486	3,163	1,421	756 a										10	52	2	46		
1991	5,415	3,639	2,160	587 a										16	75	37	79		
1992	5,729	3,522	1,935	681 a						155	139	83	62 bd						
1993	2,873	2,601	1,034	379 a	72	113	11	42	8/19-10/12 de	112	125	96	52 bd	3	30	5	66		d
1994	2,133	1,713	1,180	493 a	376	251	27	23	7/15-10/25 de	69	61	1,059	81 bd	24	19	23	18	97	0
1995	2,429	1,681	2,541	598 a	544	294	25	14	7/12-10/18 de	49	30	491	168 bd	7	14	7	19	7	6 d
1996	1,552	2,413	4,603	726 a	854	391	86	38	6/13-10/18 de	48	21	174	20 bde	10	32	13	77	15	5 d
1997	380	1,147	2,689	629 a	332	339	38	27	6/18-11/02 d	35	24	59	23 bd	7	8	26	2	11	16 d
1998	476	367	4,413	624 a	464	142	1	9	6/08-10/27 de	28	3	211	3 bd	12	6	20	3	13	11 d
1999	700	1,112	2,511	680 a	303	84	2	0	6/03-10/13 de	19	5	80	10 bd	7	2	1	3	12	11 d
2000	1,408	393	1,573	200 a	428	161	0	0	6/19-10/26 de	13	1	25	2 bd	0	0	10	10	12	18 d
2001	730	680	942	521 a	242	271	2	1	6/21-11/01 d	8	9	120	4 bd	0	0	13	7	23	33 d
2002	709	212	1,616	178 a	342	73	1	6	6/10-10/28 d	7	0	29	0 bd	0	0	14	6	2	4 d
2003	443	279	838	464 a	181	82	7	3	6/05-10/26 de	3	3	14	2 bd	0	0	6	9	4	5 d

a- Small numbers of aquaculture fish: see Tables 3.4a & b. b- Aquaculture. c- Hatchery designation to be reviewed: sea-cage fish could be among hatchery fish prior to 1994.
d- Corrected by scale analysis. e- Partial count.

Table 3. Estimated total homewater returns of wild, hatchery and aquaculture 1SW and MSW salmon destined for Mactaquac Dam, Saint John River, 1970-2003.

	Wild		Hatchery		Total (W+H)		Aquaculture[a]	
Year	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW
1970	3,057	5,712	100	0	3,157	5,712		
1971	1,709	4,715	365	77	2,074	4,792		
1972	908	4,899	285	592	1,193	5,491		
1973	2,070	2,518	1,965	505	4,035	3,023		
1974	3,656	5,811	3,991	2,325	7,647	8,136		
1975	6,858	7,441	6,374	2,210	13,232	9,651		
1976	8,147	8,177	9,074	2,302	17,221	10,479		
1977	3,977	9,712	6,992	2,725	10,969	12,437		
1978	1,902	4,021	3,044	2,534	4,946	6,555		
1979	6,828	2,754	3,827	1,188	10,655	3,942		
1980	8,482	10,924	10,793	2,992	19,275	13,916		
1981	6,614	5,766	5,627	2,728	12,241	8,494		
1982	5,174	5,528	3,038	1,769	8,212	7,297		
1983	4,555	5,783	1,564	1,104	6,119	6,887		
1984	8,311	9,779	1,451	1,115	9,762	10,894		
1985	6,526	10,436	2,018	875	8,544	11,311		
1986	7,904	6,128	862	797	8,766	6,925		
1987	5,909	4,352	3,328	480	9,237	4,832		
1988	8,930	2,625	1,250	912	10,180	3,537		
1989	9,522	4,072	1,339	469	10,861	4,541		
1990	7,263	3,329	1,533	575	8,796	3,904	8	221
1991	6,256	4,491	2,439	700	8,695	5,191	56	24
1992	6,683	4,104	2,223	778	8,906	4,882	34	16
1993	3,213	2,958	1,156	425	4,369	3,383	0	6
1994	2,276	1,844	1,258	503	3,534	2,347	0	28
1995	2,168	1,654	2,907	599	5,075	2,253	4	102
1996	1,326	2,309	5,394	1,002	6,720	3,311	3	10
1997	343	1,128	2,912	843	3,255	1,971	0	0
1998	341	320	4,641	647	4,982	967	0	4
1999	472	837	2,785	967	3,257	1,804	7	13
2000	1,343	277	1,725	267	3,068	544	3	3
2001	686	644	1,014	562	1,700	1,206	12	2
2002	634	199	1,724	177	2,358	376	5	8
2003	381	240	921	511	1,302	751	2	1

[a] 1990-94, 1SW and MSW classification based on lengths and count data; 1995-2003, count raised by estimated removals downstream of Mactaquac and adjusted according to ages from scale samples.

Table 4a. Estimated total number of virgin 1SW returns to the Saint John River, 1975-2003, from hatchery-reared smolts released at Mactaquac, 1974-2002.

Releases			Returns									
			Mactaquac								% return	
Year	Smolts	Prop 1-yr	Year	Mig ch (combined)	Dam	Native fishery	Angled main SJ	By-catch	Com-mercial	Total[a]	Unadj	Adj[b,c]
1974	337,281	0.00	1975	1,771	3,564	28	977	34		6,374	1.890	
1975	324,186	0.06	1976	2,863	4,831	219	1,129	32		9,074	2.799	
1976	297,350	0.14	1977	1,645	4,533	36	708	70		6,992	2.351	
1977	293,132	0.26	1978	777	1,779	49	369	70		3,044	1.038	
1978	196,196	0.16	1979	799	2,722	100	186	20		3,827	1.951	
1979	244,012	0.09	1980	3,072	6,687	335	640	59		10,793	4.423	
1980	232,258	0.12	1981	921	2,861	139	350		1,356	5,627	2.423	
1981	189,090	0.08	1982	828	1,464	64	267		415	3,038	1.607	
1982	172,231	0.06	1983	374	857	39	69		225	1,564	0.908	
1983	144,549	0.22	1984	476	828	36	63	48		1,451	1.004	0.976
1984	206,462	0.28	1985	454	1,288	82	128	66		2,018	0.977	0.920
1985	89,051	1.00	1986	64	635	53	93	17		862	0.968	0.868
1986	191,495	1.00	1987	152	2,063	74	222	52		2,563	1.338	1.170
1987	113,439	1.00	1988	(717)		15	46	16		794	0.700	0.672
1988	142,195	1.00	1989	(1,018)		0	107	23		1,148	0.807	0.763
1989	238,204	0.98	1990	(903)		0	57	20		980	0.411	0.401
1990	241,078	0.98	1991	(1,490)		88	108	35		1,721	0.714	0.649
1991	178,127	0.97	1992	(1,132)		26	135	26		1,319	0.740	0.688
1992	204,836	1.00	1993	(779)		11	60	17		867	0.423	0.406
1993	221,403	1.00	1994	(841)		37	0	18		896	0.405	0.393
1994	225,037	1.00	1995	(1,509)		15		15		1,539	0.684	0.661
1995 [d]	251,759	1.00	1996	(2,649)		215	0	29		2,893	1.149	1.140
1996	286,400	1.00	1997	(1,543)		58	0	16		1,617	0.565	0.558
1997	286,485	1.00	1998	(2,112)		0	0	21		2,133	0.745	0.745
1998	297,012	1.00	1999	(1,672)		0	0	17		1,689	0.569	0.468
1999	305,073	1.00	2000	(1,403)		0	0	14		1,417	0.464	0.464
2000	311,825	1.00	2001	(839)		0	0	8		847	0.272	0.272
2001	305,321	1.00	2002	(1,358)		0	0	14		1,372	0.449	0.449
2002	241,971	1.00	2003	(815)		0	0	8		823	0.340	0.340
2003	155,701	1.00	2004									

[a] Includes some returns from smolts stocked downriver of Mactaquac or escaped from sea-cages (Table 3; as determined from erosion of margins of upper and lower caudal fins).

[b] Adjusted return rates exclude smolts stocked downriver from Mactaquac (Marshall 1989) and fish of probable sea-cage origin. (Marginal numbers of returns from approx. 5,000 age 2.1 smolts, 1989-1991 are not included; no returns from tagged smolts released to the Nashwaak River, 1992 or 1997; 1997 count yielded 2 tagged 1SW fish from among 2,000 tagged smolts released to the Nashwaak in 1996 (9,017 smolts total).

[c] 1997 adjustment to return years 1995-97, based on Ad-clipped age1.1 returns from age-0+ fall fingerlings stocked above Mactaquac, 1993-95. Total estimated returns number 22, 22 and 10 in 1995, 1996 and 1997, respectively.

[d] Revised "smolts released" includes 11,177 age-1 smolts released to the migration channel from Saint John Hatchery.

Table 4b. Estimated total number of virgin 2SW returns to the Saint John River, 1976-2003, from hatchery-reared smolts released at Mactaquac, 1974-2001.

Releases			Returns									
			Mactaquac								% return	
Year	Smolts	Prop 1-yr	Year	Mig ch (combined)	Dam	Native fishery	Angled main SJ	By-catch	Com-mercial	Total[a]	Unadj	Adj[b,c]
1974	337,281	0.00	1976	310	1,313	392	267	20		2,302	0.683	
1975	324,186	0.06	1977	341	1,727	206	417	34		2,725	0.841	
1976	297,350	0.14	1978	223	1,728	368	165	50		2,534	0.852	
1977	293,132	0.26	1979	145	747	210	65	21		1,188	0.405	
1978	196,196	0.16	1980	302	1,992	506	146	46		2,992	1.525	
1979	244,012	0.09	1981	126	963	252	125		1,262	2,728	1.118	
1980	232,258	0.12	1982	88	640	462	181		398	1,769	0.762	
1981	189,090	0.08	1983	44	255	76	17		712	1,104	0.584	
1982	172,231	0.06	1984	84	722	201	5	103		1,115	0.647	0.560
1983	144,549	0.22	1985	73	492	189	5	116		875	0.605	0.553
1984	206,462	0.28	1986	16	471	266	4	40		797	0.386	0.346
1985	89,051	1.00	1987	4	338	110	4	24		480	0.539	0.453
1986	191,495	1.00	1988	(511)		150	0	35		696	0.363	0.354
1987	113,439	1.00	1989	(379)		0	0	20		399	0.352	0.330
1988	142,195	1.00	1990	(480)		0	0	25		505	0.355	0.170
1989	238,204	0.98	1991	(359)		62	0	46		467	0.196	0.173
1990	241,078	0.98	1992	(590)		58	0	32		680	0.282	0.256
1991	178,127	0.97	1993	(242)		16	0	11		269	0.151	0.145
1992	204,836	1.00	1994	(303)		10	0	23		336	0.164	0.159
1993	221,403	1.00	1995	(398)		5	0	11		414	0.187	0.187
1994	225,037	1.00	1996	(567)		18	0	15		600	0.267	0.267
1995 [d]	251,759	1.00	1997	(412)		45	0	12		469	0.186	0.186
1996	286,400	1.00	1998	(229)		0	0	6		235	0.082	0.082
1997	286,485	1.00	1999	(554)		0	0	14		568	0.198	0.198
1998	297,012	1.00	2000	(173)		0	0	4		177	0.060	0.060
1999	305,073	1.00	2001	(462)		0	0	12		474	0.155	0.155
2000	311,825	1.00	2002	(142)		0	0	4		146	0.047	0.047
2001	305,321	1.00	2003	(443)		0	0	11		454	0.149	0.149
2002	241,971	1.00										

[a]Includes some returns from smolts stocked downriver of Mactaquac or escaped from sea-cages (Table 3: erosion of margins of upper and lower caudal fins).

[b]Adjusted return rates exclude smolts stocked downriver from Mactaquac (Marshall 1989) and fish of probable sea-cage origin. (Marginal numbers of returns from approx. 5,000 age 2.1 smolts, 1989-1991 are not included; no returns from tagged smolts released to the Nashwaak River, 1992, possibly 3 returns from 12,516 smolts >12cm to Nashwaak in 1993; no returns from 15,059 stocked in the Nashwaak in 1994 and 2 returns from 3,989 tagged [13,283 total] in 1995.

[c]1997 adjustment to return year 1997 based on Ad-clipped age 1.2 returns from age-0+ fall fingerlings stocked above Mactaquac in 1994. Total estimated returns numbered 9 fish in 1997.

[d]Revised "smolts released" includes 11,177 age-1 smolts released to the migration channel from Saint John Hatchery.

Table 5. Estimated homewater removals of 1SW and MSW salmon destined for Mactaquac Dam on the Saint John River, N.B., 2003.

	1SW			MSW		
Components	Wild	Hatch	Total	Wild	Hatch	Total
Passed above Tinker	35	15	50	0	1	1
Mortality @ Beechwood	0	0	0	0	0	0
Tobique Barrier Morts	1	1	2	12	10	22
Hatchery broodfish	52	32	84	53	83	136
mortalities, etc.	1	2	3	5	8	13
Poaching/disease	7	7	14	3	2	5
By-catch [a]	4	9	13	6	13	19
Totals	**100**	**66**	**166**	**79**	**117**	**196**

[a] Wild:hatchery composition per adjusted counts and assumed availability.

Table 6. Estimated homewater returns, removals and spawning escapement of 1SW and MSW salmon destined for upstream of Mactaquac Dam, Saint John River, 2003.

Sea-age	Components	Wild	Hatch	Total
1SW				
	Homewater returns	381	921	1,302
	Homewater removals[a]	100	66	166
	Spawners	281	855	1,136
	Conservation requirement			4,900
	% of requirement			23
MSW				
	Homewater returns	240	511	751
	Homewater removals[a]	79	117	196
	Spawners	161	394	555
	Conservation requirement			4,900
	% of requirement			11

[a] Refer to Table 5 for details.

Table 7. Number, biological characteristics and estimated eggs from wild and hatchery 1SW and MSW salmon released upstream of Mactaquac, 1996 - 2003. Lengths are fork lengths in centimetres.

Sea-Age Origin	Year	Female Mean Length	Estimated Fecundity	Prop Female	Counts Escape	Total Eggs	Prop Total
Wild 1SW							
	1996	58.8	3,587	0.13	1,082	512,310	0.03
	1997	61.3	3,927	0.06	313	74,979	0.01
	1998	58.5	3,550	0.13	311	148,573	0.03
	1999	62.3	4,066	0.11	432	192,076	0.02
	2000	59.8	3,717	0.18	1,208	795,471	0.22
	2001	59.6	3,692	0.11	548	225,894	0.03
	2002	59.9	3,728	0.13	544	254,698	0.14
	2003	59.7	3,701	0.14	281	142,091	0.04
	mean	**60.0**	**3,746**	**0.12**	**590**	**293,262**	**0.06**
Hatchery 1SW							
	1996	58.8	3,584	0.12	4,394	1,858,276	0.10
	1997	62.0	4,021	0.09	2,429	898,565	0.09
	1998	58.6	3,551	0.11	4,311	1,734,600	0.29
	1999	59.5	3,672	0.10	2,530	940,495	0.09
	2000	58.0	3,486	0.09	1,587	493,507	0.14
	2001	60.8	3,855	0.04	915	144,907	0.02
	2002	60.2	3,769	0.05	1,621	287,235	0.15
	2003	58.1	3,494	0.07	855	218,951	0.06
	mean	**59.5**	**3,679**	**0.08**	**2,330**	**822,067**	**0.12**
Wild MSW							
	1996	78.6	7,313	0.86	1,700	10,704,039	0.59
	1997	77.0	6,896	0.95	786	5,143,823	0.53
	1998	79.7	7,617	0.93	188	1,330,139	0.22
	1999	78.0	7,146	0.95	582	3,963,315	0.39
	2000	77.9	7,131	0.95	129	877,003	0.25
	2001	78.0	7,149	0.95	470	3,181,509	0.49
	2002	79.5	7,557	0.90	92	623,097	0.33
	2003	77.3	6,981	0.95	161	1,063,337	0.27
	mean	**78.2**	**7,224**	**0.93**	**514**	**3,360,783**	**0.38**
Hatchery MSW							
	1996	77.0	6,906	0.92	818	5,202,829	0.28
	1997	77.8	7,102	0.93	554	3,663,027	0.37
	1998	77.3	6,976	0.88	439	2,698,884	0.46
	1999	77.5	7,021	0.94	756	4,991,116	0.49
	2000	77.6	7,051	0.98	202	1,398,869	0.39
	2001	77.0	6,903	0.90	474	2,929,761	0.45
	2002	78.4	7,263	0.83	117	702,291	0.38
	2003	76.7	6,831	0.92	394	2,487,626	0.64
	mean	**77.4**	**7,007**	**0.91**	**469**	**3,009,300**	**0.43**

Table 8. Results of electrofishing surveys in tributaries upstream of Mactaquac, 2003. A dash (-) in the recapture column indicates that a recapture pass was not completed for that particular site.

River / Site Name	Site No.	Marking Month	Marking Day	Recap Time (days)	Area (m²)	Marking Run: Hatch Fry Count	Marking Run: Wild Fry Count	Marking Run: Wild Parr Marked	Marking Run: Wild Parr Mort	Recapture Run: Hatch Fry Count	Recapture Run: Wild Fry Count	Recapture Run: Wild Parr Unmark	Recapture Run: Wild Parr Marked	Mark Run Efficiency	Wild Density / 100 m² 0+	Wild Density / 100 m² 1+	Wild Density / 100 m² 2+	Hatchery Density / 100 m² 0+	Hatchery Density / 100 m² 1+	Hatchery Density / 100 m² 2+	Mean Efficiency Used
Meduxnekeag River																					
North Br. @ Carter Brook	5	8	19	2	1218	0	0	11	0	0	0	2	3	0.647	0.0	0.3	0.0	0.0	1.1	0.0	No
Marven Brook	1	7	15	0	600	0	0	3	0	-	-	0	-	0.347	0.0	0.0	0.0	0.0	1.5	0.0	Yes
Hagerman Brook @ Oakville	4	7	15	0	718	0	0	6	0	-	-	0	-	0.347	0.0	0.0	0.0	0.0	2.4	0.0	Yes
Becaguimec River																					
Coldstream (Bannon)	1	8	18	2	1342	0	0	12	0	0	0	10	5	0.353	0.0	0.7	0.0	0.0	1.8	0.0	No
North Branch (Carlisle)	5	7	8	2	1451	0	0	28	0	0	0	20	6	0.252	0.0	5.2	0.5	0.0	1.7	0.2	No
East Coldstream (Estralon)		8	18	2	684	0	0	9	0	0	0	3	4	0.600	0.0	0.4	0.0	0.0	1.8	0.0	No
East Coldstream	2	7	21	0	1071	0	0	3	0	-	-	0	-	0.347	0.0	0.5	0.0	0.0	0.3	0.0	Yes
South Branch (County Line)	3	7	21	0	552	0	0	2	0	-	-	0	-	0.347	0.0	0.6	0.0	0.0	0.0	0.6	Yes
North Branch (Cloverdale)	4	7	8	0	1529	0	0	7	0	-	-	0	-	0.347	0.0	0.7	0.2	0.0	0.4	0.0	Yes
North Branch (Howard Brook)		7	10	0	837	0	0	22	0	-	-	0	-	0.347	0.0	2.7	2.0	0.0	2.7	0.0	Yes
Shikatehawk River																					
Lockharts Mill - Lower	1.1	9	2	2	477	0	1	89	0	0	1	77	33	0.304	0.6	54.0	7.4	0.0	0.0	0.0	No
Lockharts Mill - Upper	1.2	9	2	2	770	0	0	134	0	0	3	88	49	0.360	0.0	40.7	7.6	0.0	0.0	0.0	No
Girdonsville	2	9	2	2	1260	0	19	113	0	0	26	55	45	0.454	3.3	19.7	0.1	0.0	0.0	0.0	No
West Glassville - Lower	3.1	9	3	2	546	0	4	125	0	0	4	78	55	0.415	1.8	53.7	1.4	0.0	0.0	0.0	No
West Glassville - Upper	3.2	9	3	2	1111	0	57	193	0	0	40	126	69	0.356	14.4	48.2	0.6	0.0	0.0	0.0	No
Centre Glassville	4	9	3	0	1393	0	0	1	0	-	-	0	-	0.347	0.0	0.2	0.0	0.0	0.0	0.0	Yes
Kenneth	5	9	3	0	961	0	0	0	0	-	-	0	-	0.347	0.0	0.0	0.0	0.0	0.0	0.0	Yes
North Branch, Above Forks		8	20	0	499	0	0	0	0	-	-	0	-	0.347	0.0	0.0	0.0	0.0	0.0	0.0	Yes
Salmon River (Vic. Co.)																					
Sutherland Brook	1	9	10	0	715	0	2	8	0	-	-	0	-	0.347	0.8	2.0	0.4	0.0	0.8	0.0	Yes
Sutherland Brook 'Below'	1.2	9	10	0	446	0	0	12	0	-	-	0	-	0.347	0.0	7.2	0.0	0.0	0.0	0.7	Yes
Sutherland Brook	1.3	9	10	0	293	0	0	4	0	-	-	0	-	0.347	0.0	1.0	2.1	0.0	1.0	0.0	Yes
Above Simpson Brook	2	9	10	0	918	0	0	2	0	-	-	0	-	0.347	0.0	0.0	0.7	0.0	0.0	0.0	Yes
Above Poitras Brook	3	9	10	0	854	0	0	13	0	-	-	0	-	0.347	0.0	0.7	1.6	0.0	0.0	0.0	Yes
Tobique River																					
Saddler Brook Road	3	7	14	2	732	0	0	22	0	0	0	14	7	0.355	0.0	7.3	0.5	0.0	0.7	0.0	No
Gulquac South Branch	4	7	15	2	1259	0	0	20	0	0	0	15	7	0.339	0.0	4.6	0.0	0.0	0.1	0.0	No
Campbell Landing	7	7	12	2	1387	0	25	73	0	0	29	36	21	0.376	4.8	12.2	0.6	0.0	1.2	0.0	No
Shingle Gulch	8	7	21	2	611	0	1	38	6	0	2	23	12	0.389	0.5	16.0	1.9	0.0	0.6	0.0	No
Hazelton Landing	9	7	22	2	1442	0	8	40	1	0	6	26	8	0.258	2.1	9.7	0.8	0.0	0.5	0.0	No
Anvil Brook	10	7	22	2	1775	0	4	39	0	0	0	9	7	0.464	0.5	2.2	0.3	0.0	2.3	0.0	No
South Branch	13	7	29	2	1151	0	0	58	2	0	0	41	21	0.353	0.0	10.7	2.2	0.0	1.9	0.0	No
Three Brooks (crosses hwy 105)	16	7	8	2	1322	0	0	39	0	0	0	9	13	0.600	0.0	4.9	0.0	0.0	0.0	0.0	No
Fyke Net	1	7	16	0	889	0	0	7	0	-	-	0	-	0.347	0.0	1.9	0.3	0.0	0.0	0.0	Yes
Ben's Pole Road	2	7	14	0	2292	0	4	19	0	-	-	0	-	0.347	0.5	2.0	0.4	0.0	0.0	0.0	Yes
Burma Road	5	8	22	0	1087	0	0	7	0	-	-	0	-	0.347	0.0	1.8	0.0	0.0	0.0	0.0	Yes
Pat's Crossing	14	7	29	0	1108	0	0	4	1	-	-	0	-	0.347	0.0	1.3	0.0	0.0	0.0	0.0	Yes
Above Lawson Brook	15	7	29	0	595	0	0	6	0	-	-	0	-	0.347	0.0	1.5	0.0	0.0	1.5	0.0	Yes
Nation House	17	7	2	0	920	0	0	25	0	-	-	0	-	0.347	0.0	7.2	0.0	0.0	0.6	0.0	Yes
Bob Barr	18	7	2	0	1474	0	1	8	0	-	-	0	-	0.347	0.2	1.6	0.0	0.0	0.0	0.0	Yes
Pearl Road	20	7	2	0	580	0	0	8	0	-	-	0	-	0.347	0.0	3.5	0.5	0.0	0.0	0.0	Yes
River Don - Just above Forks	23	7	15	0	816	0	1	38	0	-	-	0	-	0.347	0.4	12.1	1.1	0.0	0.4	0.0	Yes
Odell, Kate Finnamores		7	11	0	1591	0	0	13	0	-	-	0	-	0.347	0.0	2.3	0.0	0.0	0.0	0.0	Yes
Odell, Twin Bridges		7	11	0	780	0	0	9	0	-	-	0	-	0.347	0.0	0.0	0.0	0.0	1.3	0.0	Yes
Gulquac North Branch		7	17	0	750	0	0	7	0	-	-	0	-	0.347	0.0	0.4	0.4	0.0	1.9	0	Yes
River Dom - Bridge To Nowhere		7	23	0	660	0	0	26	0	-	-	0	-	0.347	0.0	9.6	0.0	0.0	1.8	0.0	Yes
Mamozekel, 10.5km barrier bdg.		8	22	0	448	0	1	1	0	-	-	0	-	0.347	0.7	0.7	0.0	0.0	0.0	0.0	Yes

Table 9. Total smolt catches at smolt wheel(s) and a trapnet on the Tobique River and in the intake gatewells at Beechwood Dam, from 2000 to 2003. The numbers of marked smolts released, recycled and/or recaptured are also indicated for each location.

Year	Catch/Release	Details	Tobique		Beechwood
			Smolt Wheel(s) [a]	Trapnet	Intake Gatewells
2000	Catch	Wild	70	6	n/a
		Hatchery Fall Fingerling (HFF)	8	-	n/a
		Hatchery Spring Smolt	-	16	n/a
	Marked	Released at wheel - Wild/HFF	78	n/a	n/a
		Untagged - Hatchery Spring [b]	1,996	n/a	n/a
	Recaptures	Released at RST - Wild/HFF	n/a	-	n/a
		Untagged - Hatchery Spring	-	16	n/a
2001	Catch	Wild	176	27	585
		Hatchery Fall Fingerling	86	8	47
	Marked	Recycled - Wild/HFF	149	-	n/a
		Garment - Hatchery Spring [b]	n/a	n/a	n/a
	Recaptures	Recycled - Wild/HFF	11	2	7 [c]
		Garment - Hatchery Spring	n/a	n/a	n/a
2002	Catch	Wild	318	n/a	289
		Hatchery Fall Fingerling	176	n/a	12
		Unknown Origin	2	n/a	-
		Garment - Hatchery Spring	97	n/a	32
	Marked	Recycled - Wild/HFF	422	n/a	n/a
		Garment - Hatchery Spring [b]	2,357	n/a	n/a
	Recaptures	Recycled - Wild/HFF	22	n/a	4
		Garment - Hatchery Spring	97	n/a	32
2003	Catch	Wild	119	n/a	463
		Hatchery Fall Fingerling	50	n/a	32
		Unknown Origin	-	n/a	15
		Garment - Hatchery Spring	21	n/a	18
	Marked	Recycled - Wild/HFF	139	n/a	n/a
		Garment - Hatchery Spring [b]	1,483	n/a	n/a
	Recaptures	Recycled - Wild/HFF	6	n/a	6
		Garment - Hatchery Spring	21	n/a	18

[a] Smolt wheel catch excludes recaptures since it would not be included in estimating populations.
[b] Hatchery released spring smolts (untagged and garment tagged) were released above the smolt wheel(s).
[c] One additional smolt, tagged as a presmolt the previous fall (October 2000), was also recaptured.

Table 10. Number and status of wild and hatchery juvenile Atlantic salmon collected during the fall season, for the captive-reared broodstock program at Mactaquac Biodiversity Facility, from the Tobique River and at Beechwood.

		Pre-Smolt		Parr		Fry		Adults	Number	Current	Year of
Year	Location	Wild	Hatchery [1]	Wild	Hatchery [1]	Wild	Total	Released	on Hand [2]	Stage	Spawning
2001	Nictau	603	3	756	2	48	1,412				
2001	Three Brooks	555	5	119	1	437	1,117				
Total (2001)		**1,158**	**8**	**875**	**3**	**485**	2,529	387	1,332	adult	2003,2004
2002	Nictau	338	1	298	23	5	**665**				
2002	Three Brooks	1,439	4	250	-	170	**1,863**				
2002	Beechwood	832	1	5	-	-	**838**				
Total (2002)		**2,609**	**6**	**553**	**23**	**175**	3,366		2,278	post-smolt	2004,2005
2003	Nictau	984	57	724	22	-	**1,787**				
2003	Three Brooks	560	26	218	-	-	**804**				
Total (2003)		**1,544**	**83**	**942**	**22**	**-**	2,591		2,462	pre-smolt	2005,2006
Grand Total		**5,311**	**97**	**2,370**	**48**	**660**	8,486		6,072		

[1] Stocked previous year as fall fingerling.

[2] Number of fish at Mactaquac Biodiversity Facility as of December 2003. Excludes mortalities and releases.

Table 11. Start and finish dates for the operation of an adult salmon counting fence on the Nashwaak River as well as the assessment technique used to estimate the total returns to the river upstream of the fence site. Also indicated are dates in which the counting fence was not fishing due to high water.

Year	Start and Finish Date	Days in which fence was not fishing 100%	Assessment Technique
1972	Aug 18 - Oct 29	Sept 4-6, Oct 8-9, Oct 25-28	
1973	Jun 10 - Nov 5	July 5-11, Aug 3-7	
1975	Jun 28 - Oct 29	Oct 21-22	
1993	Aug 19 - Oct 12		Historical Run Timing
1994	Jul 15 - Oct 25		Seining; Mark Recap
1995	Jul 12 - Oct 18		Historical Run Timing
1996	Jun 13 - Oct 18	July 9-10, July 14-31	Seining; Mark Recap
1997	Jun 18 - Nov 2		Count; No Washouts
1998	Jun 8 - Oct 27	Aug 12-14, Oct 2-5	Seining; Mark Recap
1999	Jun 3 - Oct 13	Sept 17-20, Sept 23-28	Seining; Mark Recap
2000	Jun 19 - Oct 26	Oct 10-11	Seining; Mark Recap
2001	Jun 21 - Nov 1	Aug 3-17 [a]	Count; No Washouts
2002	Jun 10 - Oct 28		Count; No Washouts
2003	Jun 5 - Oct 26	Aug 6-8, Oct 15-17, Oct 21-23	Seining; Mark Recap

[a] Fence was removed and base crib was raised 18 inches.

Table 12. Estimated returns, escapement, and percent of conservation attained for the Nashwaak River, 1993 - 2003.

Year	Estimated Returns 1SW	Estimated Returns MSW	Escapement 1SW	Escapement MSW	% of Requirement 1SW	% of Requirement MSW	Total Egg Deposition % of Requirement
1993	954	555	866	555	42%	27%	31%
1994	661	388	610	349	30%	17%	26%
1995	940	436	940	436	46%	21%	33%
1996	1829	657	1804	641	88%	31%	48%
1997	370	366	364	362	18%	18%	23%
1998	1259	315	1238	309	61%	15%	31%
1999	665	275	658	269	32%	13%	19%
2000	509	192	489	189	24%	9%	15%
2001	244	272	224	266	11%	13%	16%
2002	343	79	320	69	16%	3%	6%
2003	297	113	280	109	14%	5%	7%
Conservation Requirement:					2040	2040	12.8 Million Eggs

Table 13. Estimates of the wild smolt emigration, (and 95% confidence intervals) and smolt-to-adult return rates for the Nashwaak River upstream of Durham Bridge, 1998 – 2003.

	Wild Smolt Estimate			Return Rate (%)	
Year	Mode	2.5%	97.5%	1SW	2SW
1998	22,750	17,900	32,850	2.91	0.67
1999	28,500	25,300	33,200	1.79	0.84
2000	15,800	13,400	19,700	1.53	0.28
2001	11,000	8,100	17,400	3.11	0.90
2002	15,000	12,300	19,000	1.91	
2003	9,000	6,800	13,200		
Mean 1998-03	17,000			2.25	0.67

Table 14. Results of electrofishing surveys in tributaries downstream of Mactaquac, 2003. A dash (-) in the recapture column indicates that a recapture pass was not completed for that particular site.

River	Site	Marking		Recap Time		Marking Run				Recapture Run				Mark Run	Wild Density / 100 m²			Hatchery Density / 100 m²			Mean Efficiency
						Hatch	Wild			Hatch	Wild										
						Fry	Fry	Parr		Fry	Fry	Parr									
Site Name	No	Month	Day	(days)	Area (m²)	Count	Count	Marked	Mort	Count	Count	Unmark	Marked	Efficiency	0+	1+	2+	0+	1+	2+	Used
Canaan River																					
Neales Brook	1	9	2	2	620	0	1	13	0	0	1	1	6	0.867	0.2	2.4	0.0	0.0	0.0	0.0	No
Thom's Brook	2	9	2	0	1241	0	14	7	0	-	-	0	-	0.347	3.2	1.1	0.5	0.0	0.0	0.0	Yes
Hammond River																					
Hanford Brook - Lower	3.1	9	10	2	1779	0	31	108	0	0	53	48	39	0.452	3.9	12.1	1.2	0.0	0.0	0.1	No
Hanford Brook - Upper	3.2	9	10	2	724	1	2	10	0	0	2	5	4	0.476	0.6	2.3	0.2	0.3	0.4	0.0	No
Burke's Farm	4	9	9	2	1424	0	33	49	0	0	55	44	17	0.287	8.1	11.2	0.8	0.0	0.0	0.0	No
Hillsdale - Lower	5.1	9	9	2	1010	0	83	49	0	0	78	28	22	0.445	18.4	9.2	1.3	0.0	0.3	0.1	No
Hillsdale - Upper	5.2	9	9	2	749	0	19	38	0	0	18	17	10	0.388	6.5	10.5	2.1	0.0	0.5	0.0	No
Smithtown	2	9	8	0	1527	0	1	8	0	-	-	0	-	0.347	0.2	0.8	0.8	0.0	0.0	0.0	Yes
French Village		9	11	0	790	0	0	0	0	-	-	0	-	0.347	0.0	0.0	0.0	0.0	0.0	0.0	Yes
Kennebecasis River																					
Mt. Pisgah, Smiths Creek	1	8	25	2	1735	0	27	30	0	0	18	24	16	0.306	5.1	5.3	0.3	0.6	0.0	0.0	No
Goshen - Lower	5.1	8	26	0	581	0	3	0	0	0	0	0	0	0.347	1.5	0.0	0.0	0.0	0.0	0.0	Yes
Goshen - Upper	5.2	8	26	0	650	0	3	0	0	0	0	0	0	0.347	1.4	0.0	0.0	0.0	0.0	0.0	Yes
Millstream - Lower	6.1	8	25	2	644	0	4	10	0	0	5	6	3	0.370	1.7	4.2	0.0	0.0	0.0	0.0	No
Millstream - Upper	6.2	8	25	2	705	0	39	20	1	0	32	2	11	0.840	6.5	3.3	0.2	0.0	0.0	0.0	No
Penobsquis - Lower	3.1	8	26	0	568	0	13	0	0	-	-	0	-	0.347	6.5	0.0	0.0	0.0	0.0	0.0	Yes
Penobsquis - Upper	3.2	8	26	0	862	0	19	15	0	-	-	0	-	0.347	6.4	4.3	0.7	0.0	0.0	0.0	Yes
South Branch	4	8	25	0	959	0	0	0	0	-	-	0	-	0.347	0.0	0.0	0.0	0.0	0.0	0.0	Yes
Millstream Pleasant Ridge		8	28	0	588	0	10	27	0	-	-	0	-	0.347	4.9	12.6	0.5	0.0	0.0	0.0	Yes
Smith Creek Below Mt Pisgah		8	28	0	830	0	2	13	0	-	-	0	-	0.347	0.7	4.5	0.0	0.0	0.0	0.0	Yes
Nashwaak River																					
Penniac Stream	1	7	29	2	192	0	15	18	0	0	7	15	6	0.305	5.5	6.4	0.2	0.0	0.0	0.0	No
Above Durham Bridge	2	9	5	0	1296	0	23	1	0	-	-	0	-	0.347	5.1	0.0	0.2	0.0	0.0	0.0	Yes
Tay River	3	8	20	2	979	0	14	28	0	0	16	16	5	0.267	5.4	10.5	0.2	0.0	0.0	0.0	No
Tay River (North)	3a	8	14	0	810	0	49	31	0	-	-	0	-	0.347	17.4	8.2	2.8	0.0	0.0	0.0	Yes
Tay River (South)	3b	8	14	0	1193	0	62	36	0	-	-	0	-	0.347	15.0	8.2	0.5	0.0	0.0	0.0	Yes
MacKenzie Brook	4	7	29	2	923	0	0	1	0	0	0	3	0	0.347	0.0	0.2	0.1	0.0	0.0	0.0	Yes
Youngs Brook	4a	9	3	0	861	0	17	24	0	-	-	0	-	0.347	5.7	7.0	1.0	0.0	0.0	0.0	Yes
Above Nashwaak Bridge	5	7	28	0	1258	0	11	0	0	-	-	0	-	0.347	2.5	0.0	0.0	0.0	0.0	0.0	Yes
Cross Creek	6	9	3	0	1136	0	56	51	0	-	-	0	-	0.347	14.2	11.6	1.3	0.0	0.0	0.0	Yes
Cross Creek (Hay 625)	6a	8	13	2	964	0	2	45	0	0	0	10	14	0.592	0.3	6.3	1.6	0.0	0.0	0.0	No
Cross Creek (new 2003)	6b	8	12	0	925	0	0	23	0	-	-	0	-	0.347	0.0	4.9	2.2	0.0	0.0	0.0	Yes
Below Stanley	7	7	30	2	1164	0	9	14	0	0	5	3	3	0.560	1.4	1.5	0.6	0.0	0.0	0.0	No
Above Stanley	8	8	20	2	1207	0	5	12	0	0	5	3	3	0.545	0.7	0.7	1.1	0.0	0.0	0.0	No
Ryan Brook	8a	9	4	0	710	0	3	12	0	-	-	0	-	0.347	1.3	4.9	0.0	0.0	0.0	0.0	Yes
Napadogan Stream	8b	9	23	2	827	0	22	26	0	0	24	18	6	0.274	9.7	9.1	1.3	0.0	0.5	0.5	No
Cedar Bridge	9	8	19	2	1279	0	15	38	0	0	17	23	6	0.229	5.2	10.7	2.1	0.0	0.0	0.2	No
Doughboy Brook - Lower	10.1	8	19	2	1107	0	10	18	0	0	6	15	3	0.202	4.4	3.9	0.7	0.0	1.7	1.7	No
Doughboy Brook - Upper	10.2	8	19	2	612	0	7	13	0	0	14	10	3	0.271	4.2	4.7	1.7	0.0	0.7	0.7	No
Below Gorby Gulch	11a	9	25	0	966	0	34	22	0	-	-	0	-	0.347	10.1	5.0	1.5	0.0	0.0	0.0	Yes
Keswick River																					
Jones Forks	1	8	25	2	1084	0	8	32	0	0	12	12	12	0.516	1.5	5.7	0.0	0.0	0.0	0.0	No
Hayne	4	8	26	2	1099	0	7	40	0	0	5	27	10	0.284	2.3	11.3	1.5	0.0	0.0	0.0	No
Barton	5	8	26	2	1172	0	15	24	0	0	9	17	12	0.421	3.1	4.1	0.8	0.0	0.0	0.0	No
Stoneridge	3	8	25	0	1070	0	47	10	0	-	-	0	-	0.347	12.6	2.7	0.0	0.0	0.0	0.0	Yes
Zealand Station	2	8	27	0	845	0	70	5	0	-	-	0	-	0.347	23.9	1.7	0.0	0.0	0.0	0.0	Yes
East Branch (Mill Road)		9	2	0	496	0	14	11	0	-	-	0	-	0.347	8.1	5.3	1.2	0.0	0.0	0.0	Yes
West Branch (Mill Road)		9	2	0	787	0	0	0	0	-	-	0	-	0.347	0.0	0.0	0.0	0.0	0.0	0.0	Yes

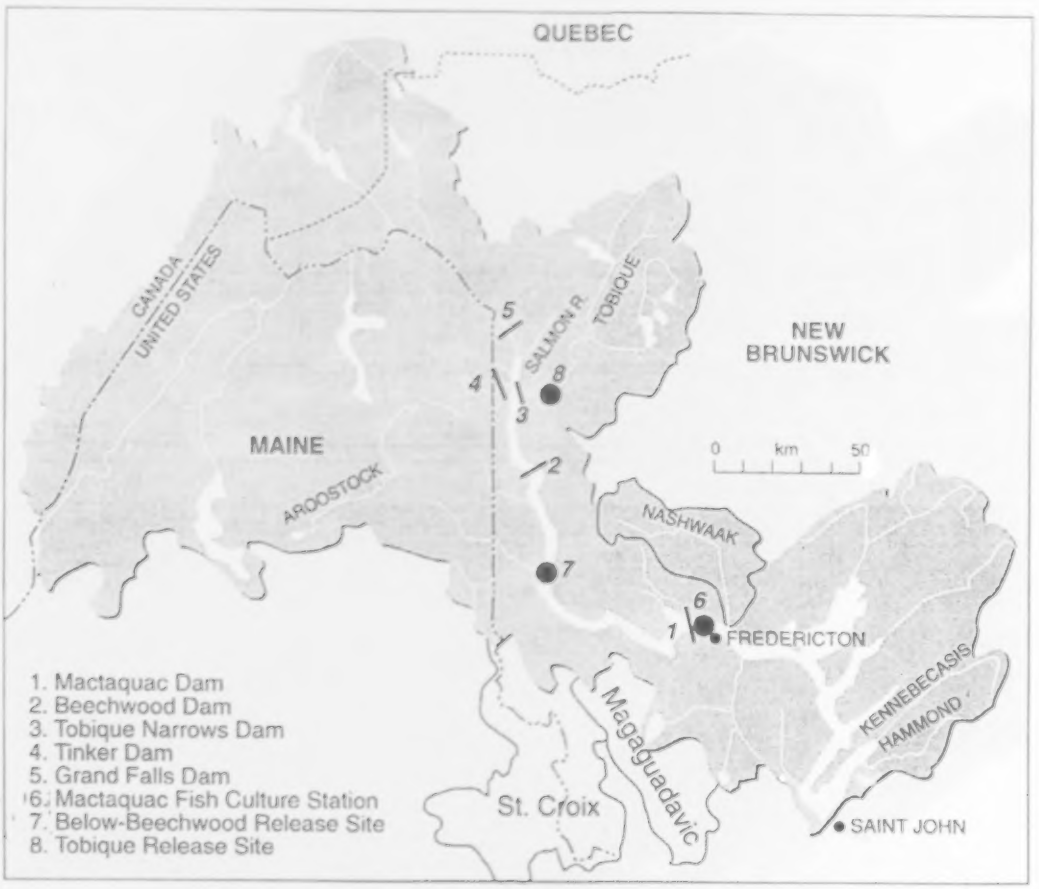
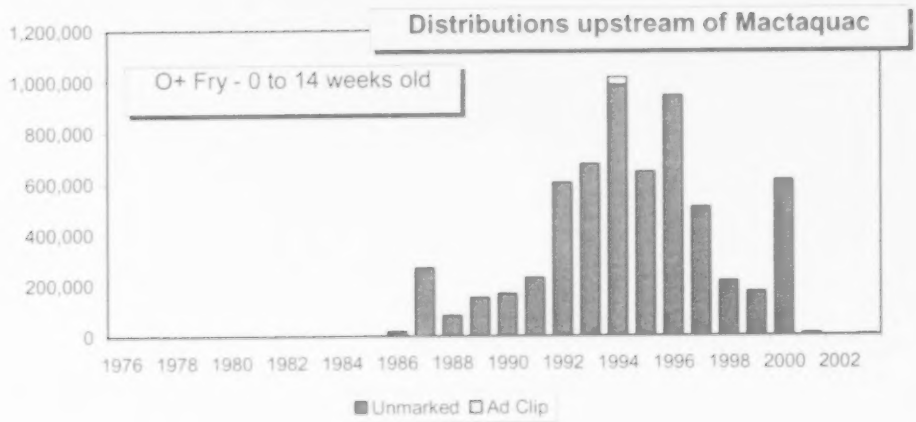


Fig. 1. Map of the Magaguadavic, St. Croix and Saint John River drainages including Tobique and Nashwaak rivers and other major tributaries, dams, and principal release sites for Atlantic salmon upstream of Mactaquac Dam. Fish trapping locations on the Tobique and Nashwaak drainages are shown in Figs. 10 and 16. Note that the Mactaquac Fish Culture Station is now referred to as the Mactaquac Biodiversity Facility.



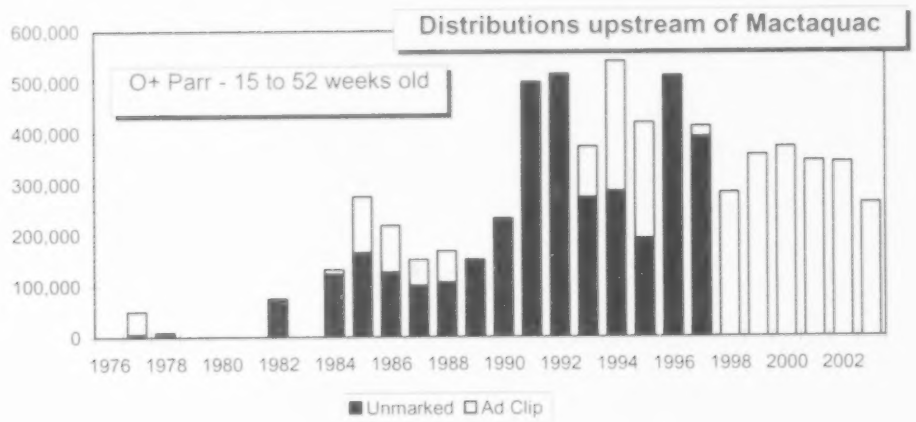


Fig. 2. Number of juvenile salmon less than 52 weeks old (excludes age-1 smolts) released or distributed to tributaries upstream of Mactaquac Dam, Saint John River, 1976 - 2003.

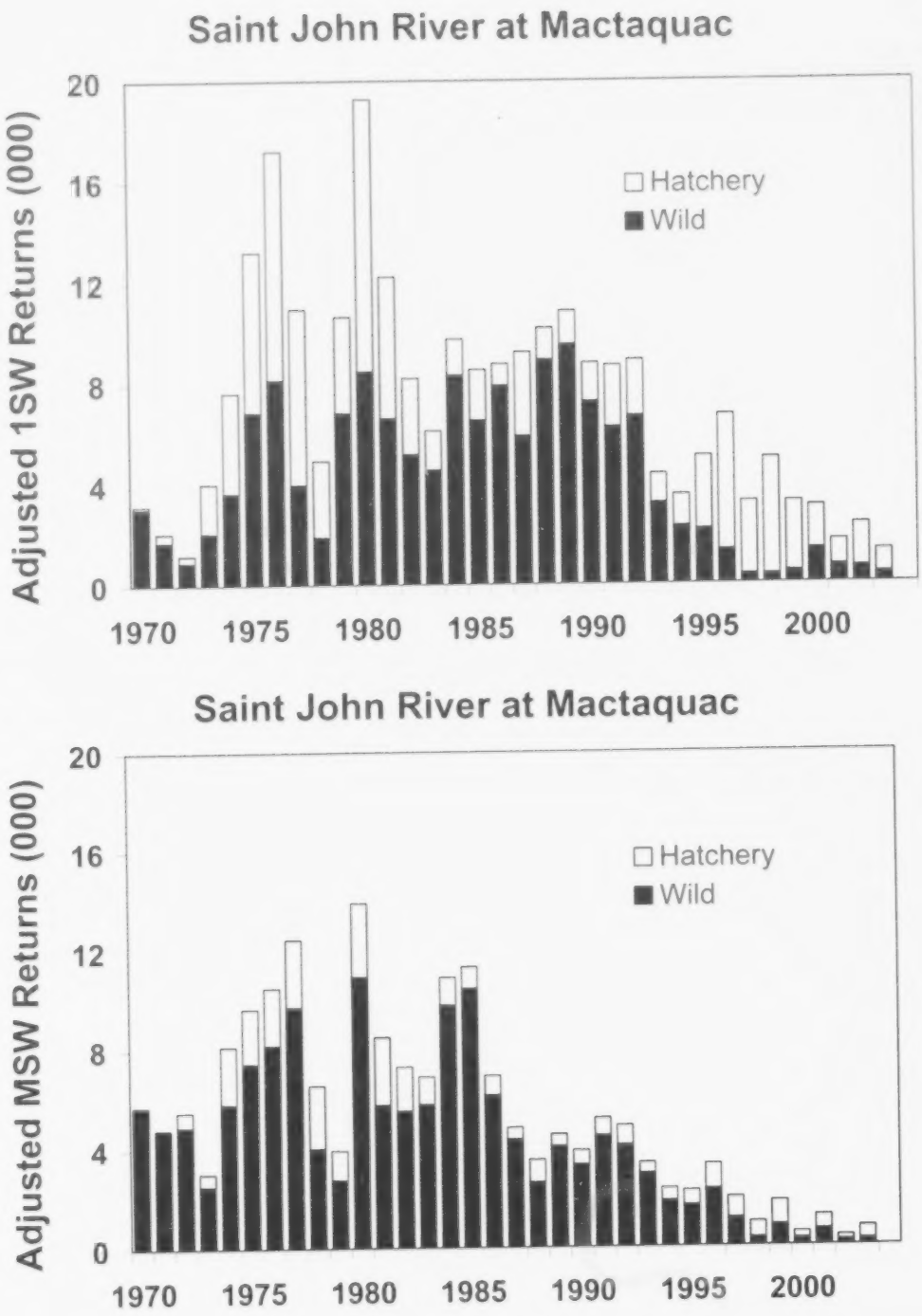


Fig. 3. Estimated total adjusted returns of wild and hatchery 1SW and MSW salmon destined for Mactaquac Dam, Saint John River, 1970 - 2003.

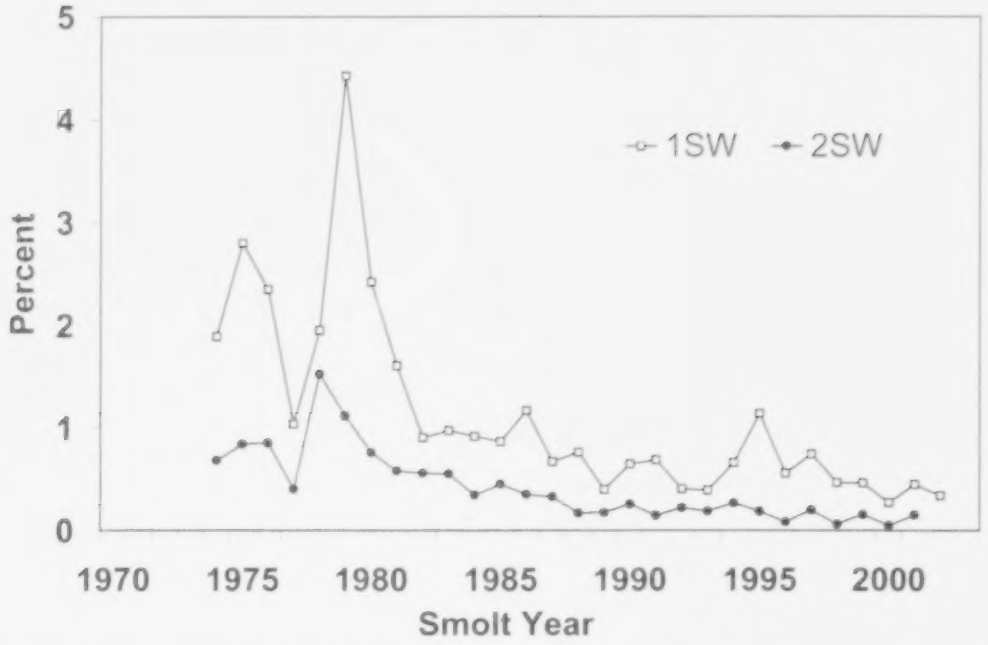


Fig. 4. Return rates of hatchery reared smolts to virgin 1SW and virgin 2SW salmon destined for Mactaquac Dam, Saint John River, by smolt year, 1974 – 2002.

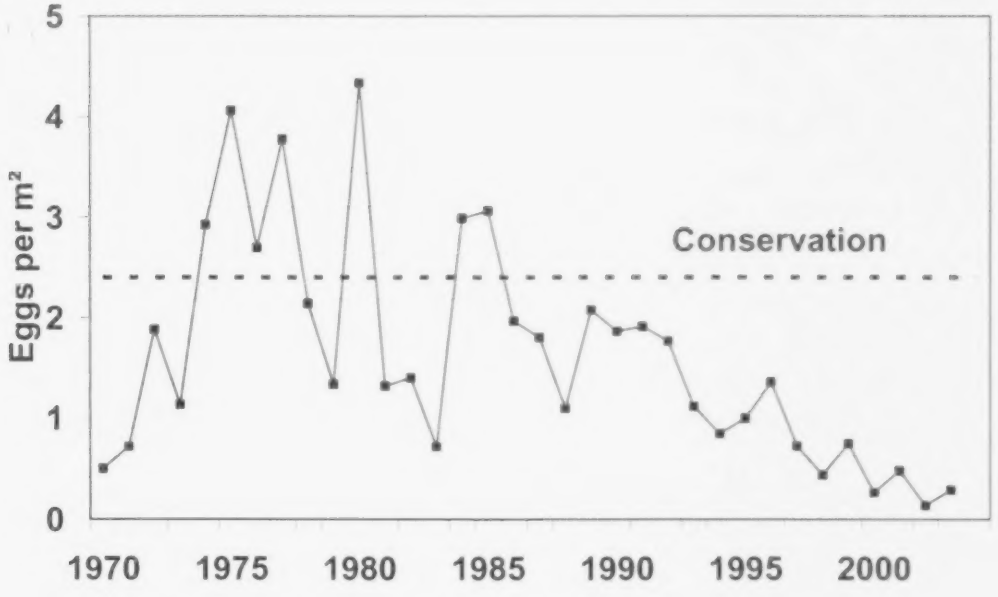


Fig. 5. Estimated egg deposition upstream of Mactaquac Dam, Saint John River, 1970 - 2003.

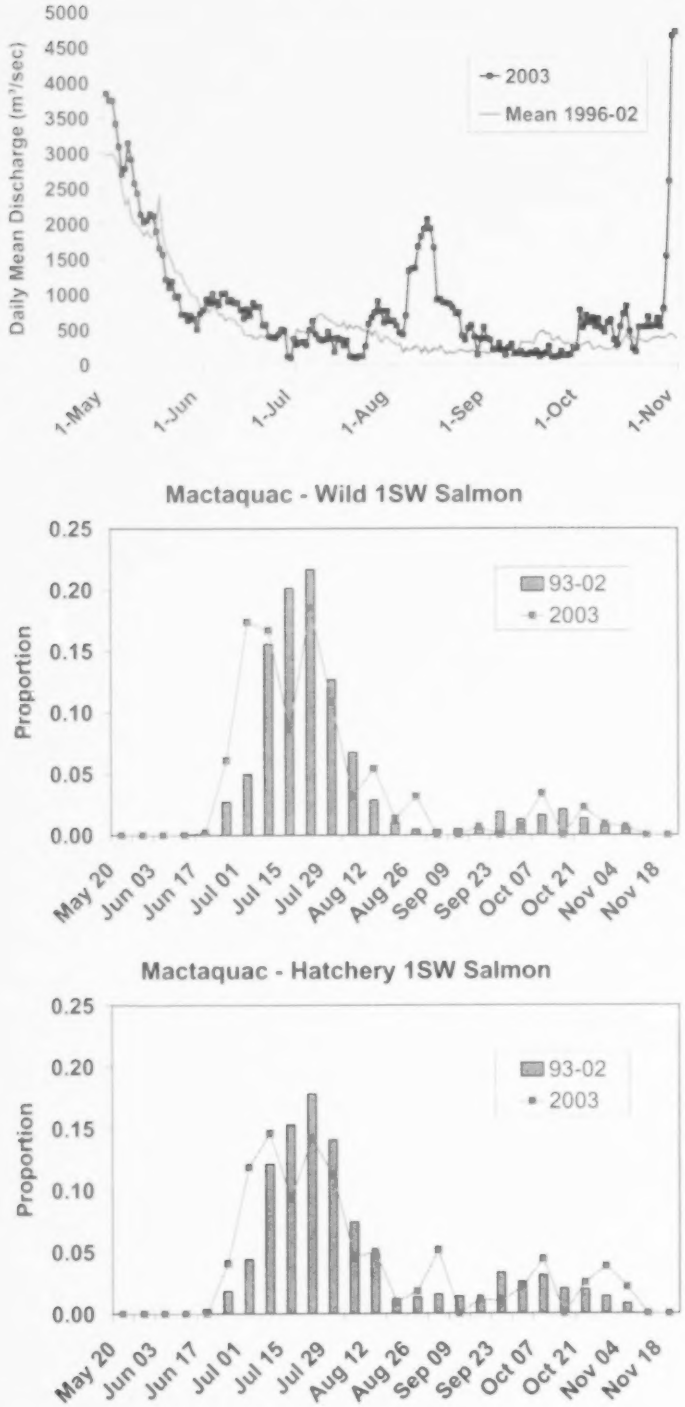


Fig. 6. Mean daily discharge (m^3/sec) from 1996 to 2002 and mean weekly counts (1993 to 2002) of wild and hatchery 1SW salmon at Mactaquac Dam compared to 2003.

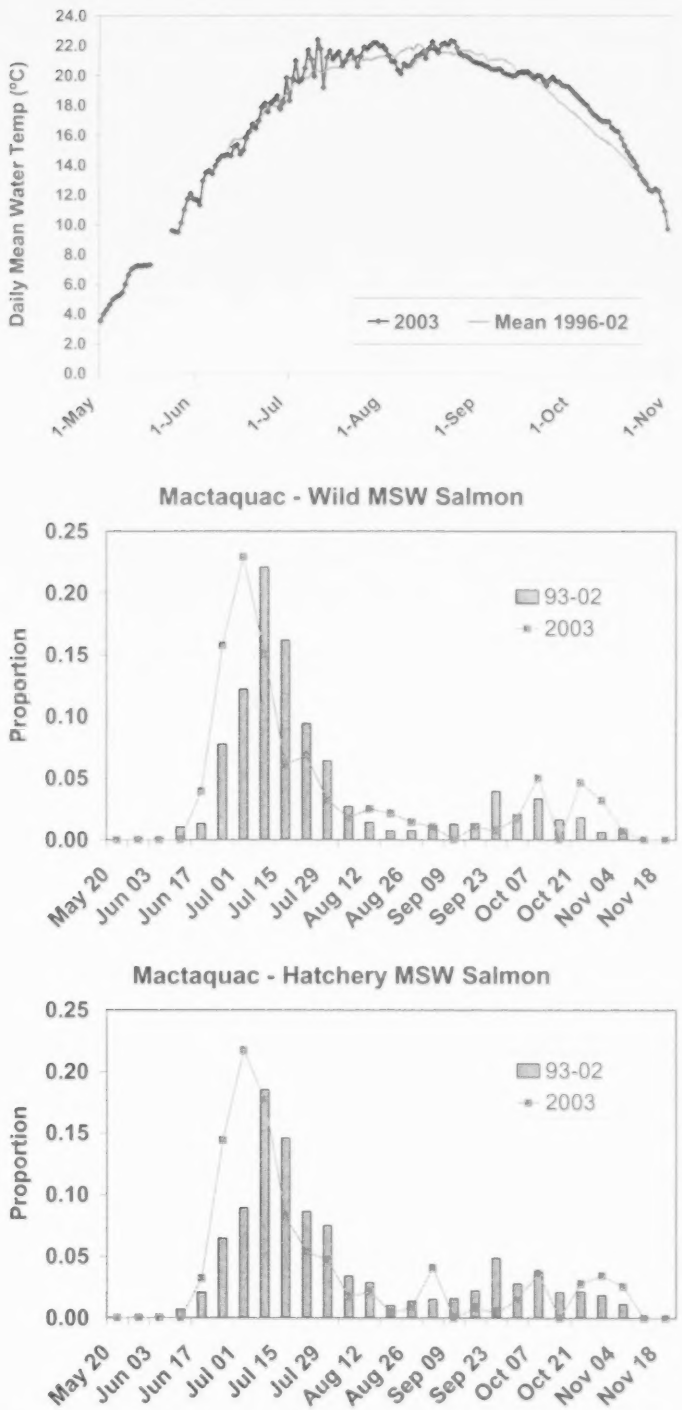


Fig. 7. Mean daily water temperatures (°C) from 1996 - 2002 and mean weekly counts (1993 - 2002) of wild and hatchery MSW salmon at Mactaquac Dam compared to 2003.

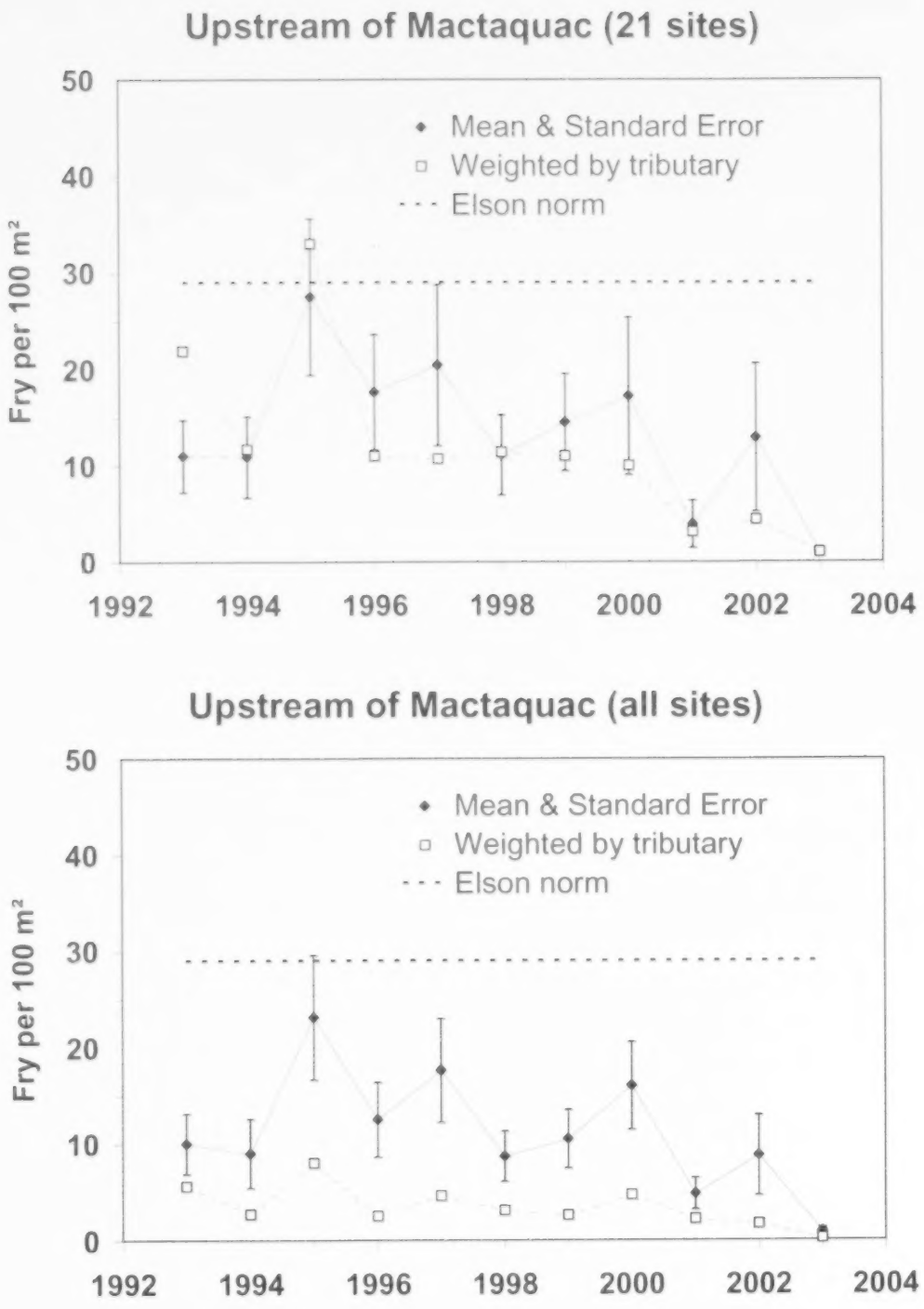


Fig. 8. Mean densities of age 0+ parr or fry from electrofishing sites located upstream of Mactaquac Dam in relation to the "Elson Norm" from 1993 to 2003.

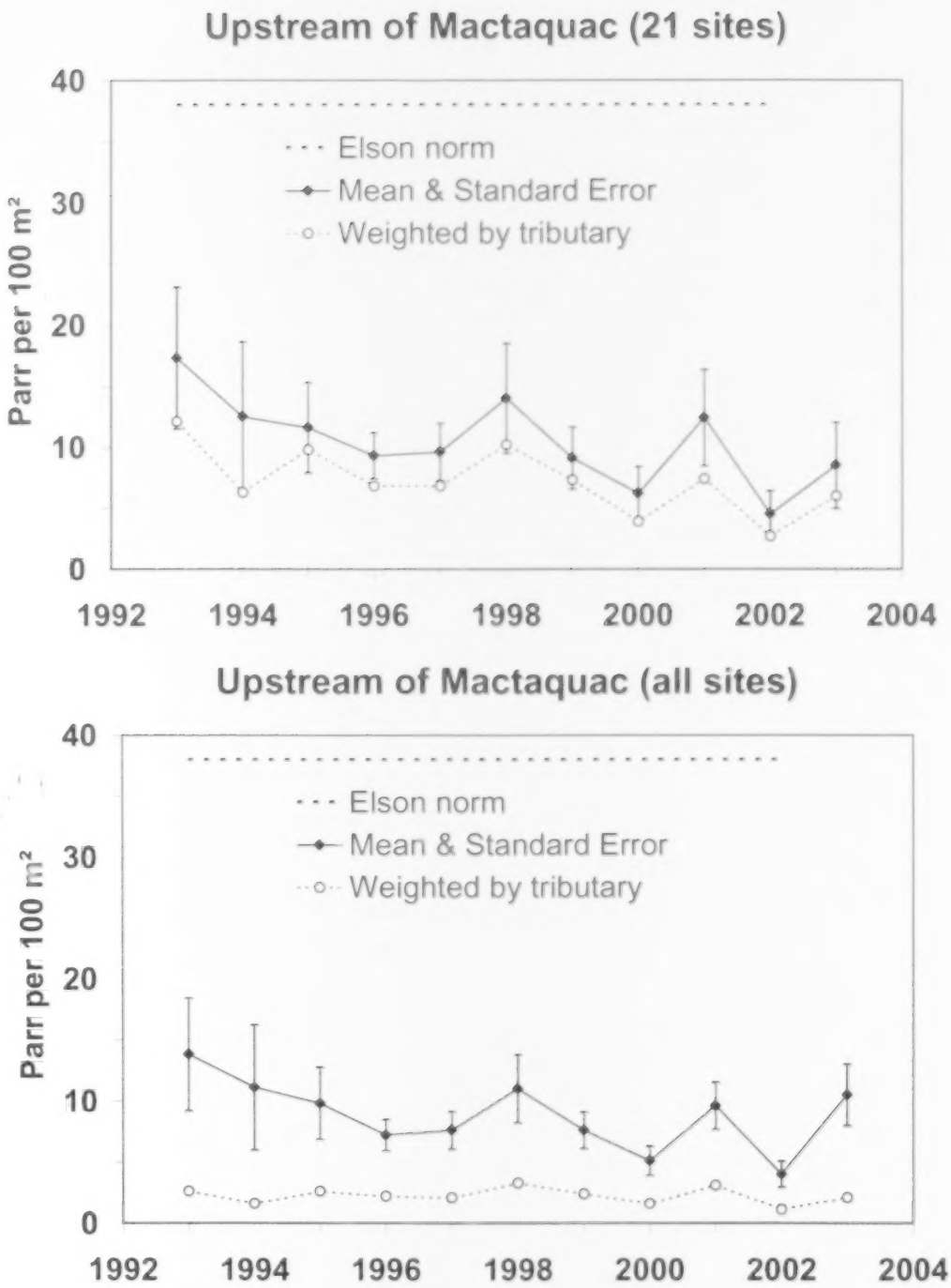


Fig. 9. Mean densities of age 1+ and older parr from electrofishing sites located upstream of Mactaquac Dam in relation to the "Elson Norm" from 1993 to 2003.

Fig. 10. Map of Tobique River showing the location of the rotary screw traps (circles), release sites for smolts (squares) and adults (diamonds), the temperature recorder, the trapnet, the half mile fish protection barrier and river gauging station sites.

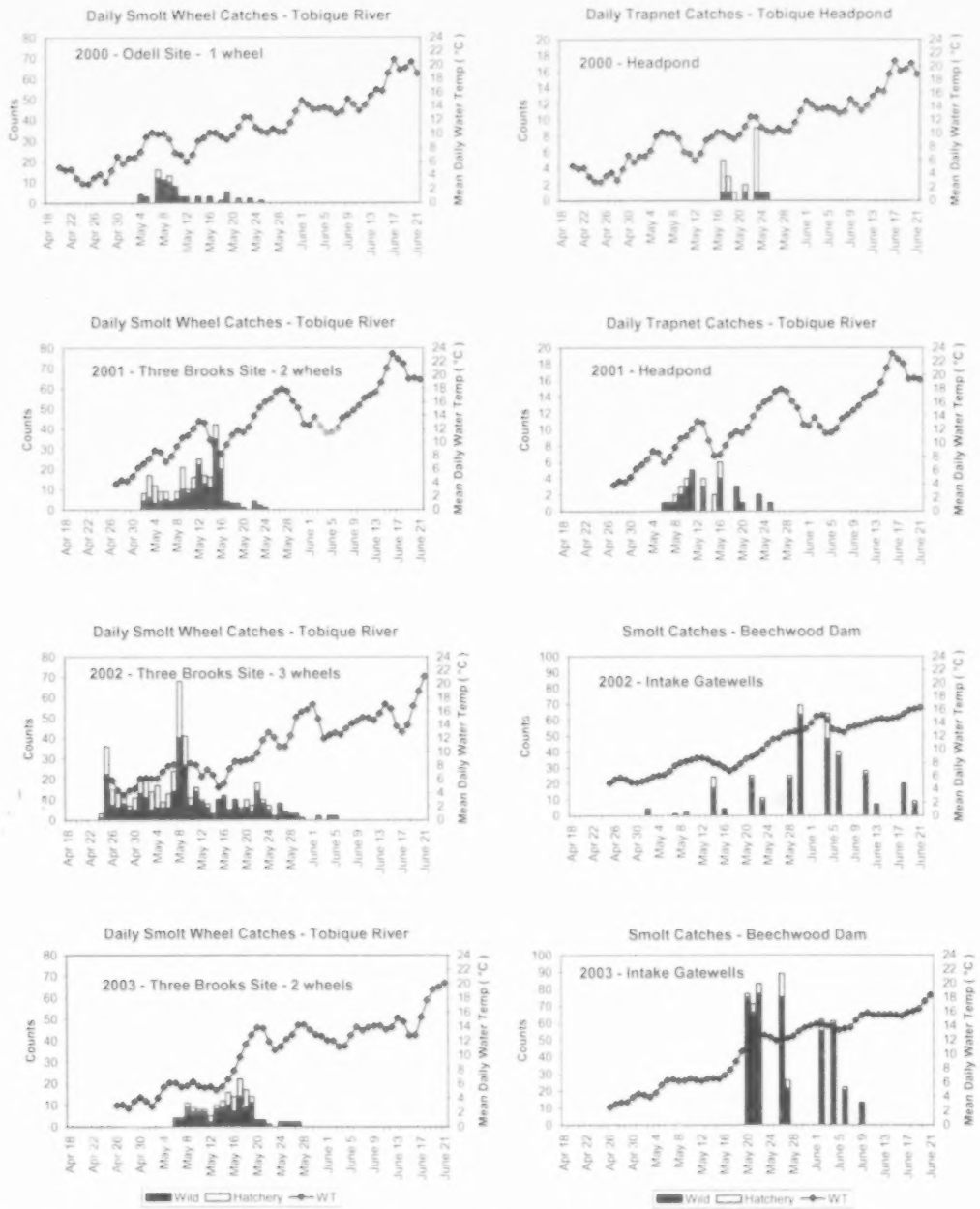

Daily Smolt Wheel Catches - Tobique River
2000 - Odell Site - 1 wheel
Daily Trapnet Catches - Tobique Headpond
2000 - Headpond
Daily Smolt Wheel Catches - Tobique River
2001 - Three Brooks Site - 2 wheels
Daily Trapnet Catches - Tobique River
2001 - Headpond
Daily Smolt Wheel Catches - Tobique River
2002 - Three Brooks Site - 3 wheels
Smolt Catches - Beechwood Dam
2002 - Intake Gatewells
Daily Smolt Wheel Catches - Tobique River
2003 - Three Brooks Site - 2 wheels
Smolt Catches - Beechwood Dam
2003 - Intake Gatewells
Counts
Mean Daily Water Temp (°C)
Wild
Hatchery
WT

Fig. 11. Daily wild and hatchery smolt catches at smolt wheel(s) and a trapnet on the Tobique River and Beechwood Intake Gatewells, 2000 – 2003. The mean daily water temperature (°C) at Arthurette (Tobique plots) and Mactaquac tailrace (Beechwood plots) is shown.

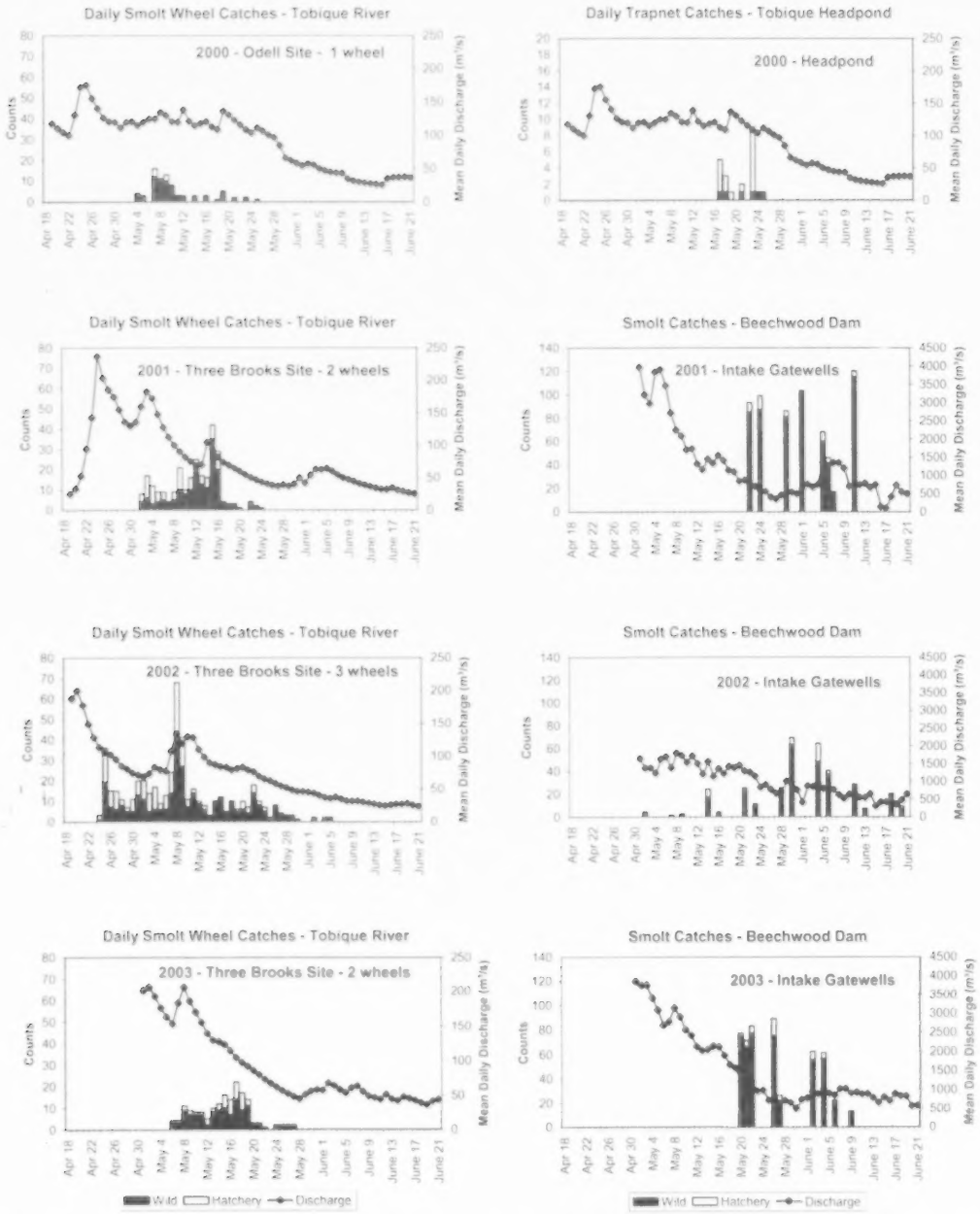
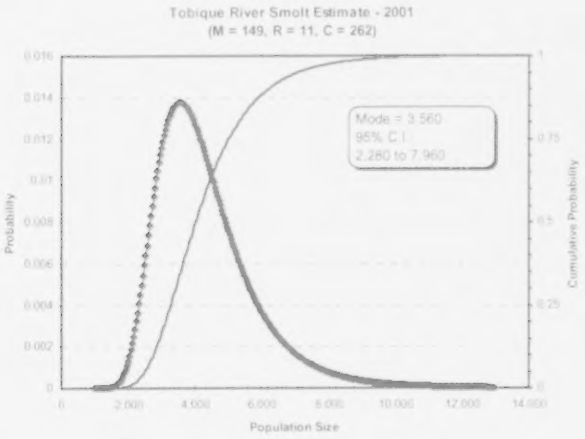
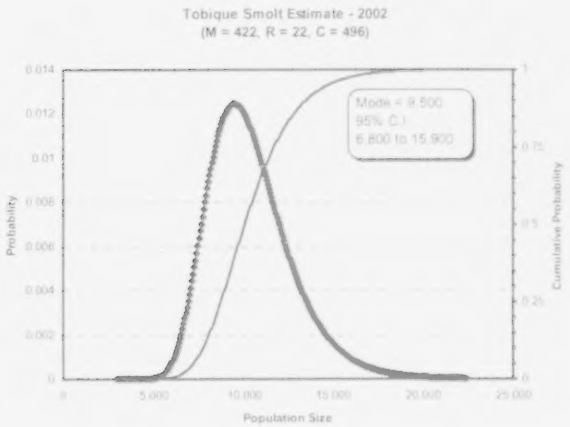

Daily Smolt Wheel Catches - Tobique River
2000 - Odell Site - 1 wheel
Daily Trapnet Catches - Tobique Headpond
2000 - Headpond
Daily Smolt Wheel Catches - Tobique River
2001 - Three Brooks Site - 2 wheels
Smolt Catches - Beechwood Dam
2001 - Intake Gatewells
Daily Smolt Wheel Catches - Tobique River
2002 - Three Brooks Site - 3 wheels
Smolt Catches - Beechwood Dam
2002 - Intake Gatewells
Daily Smolt Wheel Catches - Tobique River
2003 - Three Brooks Site - 2 wheels
Smolt Catches - Beechwood Dam
2003 - Intake Gatewells
Counts
Mean Daily Discharge (m³/s)
Wild
Hatchery
Discharge

Fig. 12. Wild and hatchery smolt catches at smolt wheels and a trapnet on the Tobique River and at the intake gatewells at Beechwood Dam, 2000 - 2003. Mean daily discharge at Riley Brook (Tobique plots) and at Mactaquac (Beechwood plots) is shown.





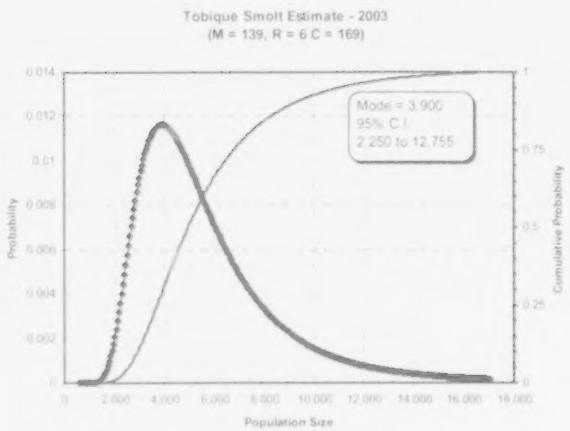


Fig. 13. Probability density (dots) and cumulative probability (black line), estimated using mark-recapture techniques, for the number of wild and hatchery Atlantic salmon smolts emigrating from the Tobique River, 2001 - 2003.

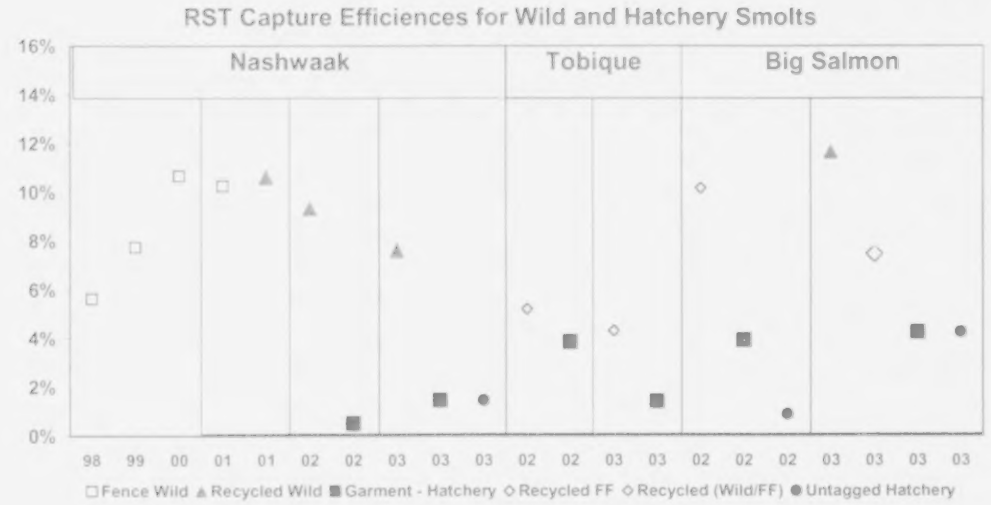


Fig. 14. Various rotary screw trap (or smolt wheel) capture efficiencies of wild, hatchery – fall fingerling (FF), hatchery -spring released (untagged and tagged) smolts from the Tobique, Nashwaak, and Big Salmon rivers (Big Salmon River data from Gibson et al. 2004).

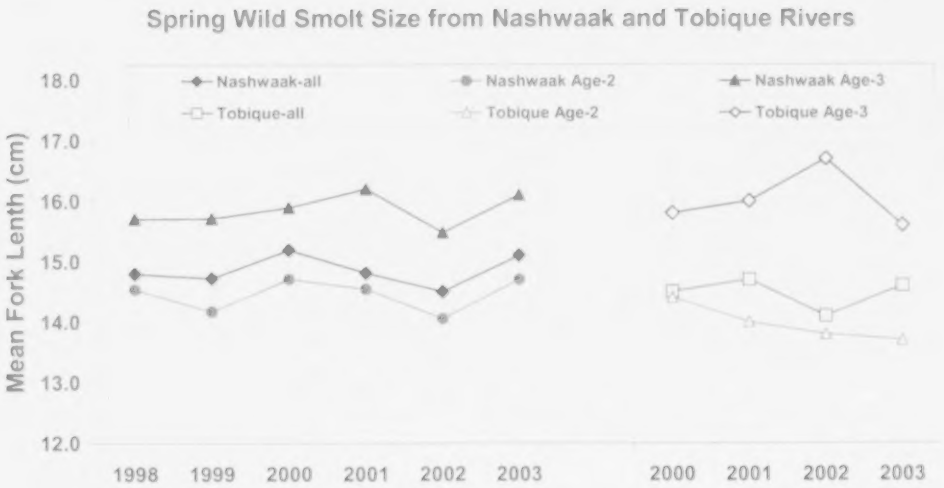


Fig. 15. Mean fork length, by age, for wild smolts sampled during assessment projects on the Nashwaak (1998 - 2003) and Tobique (2000 - 2003) rivers.

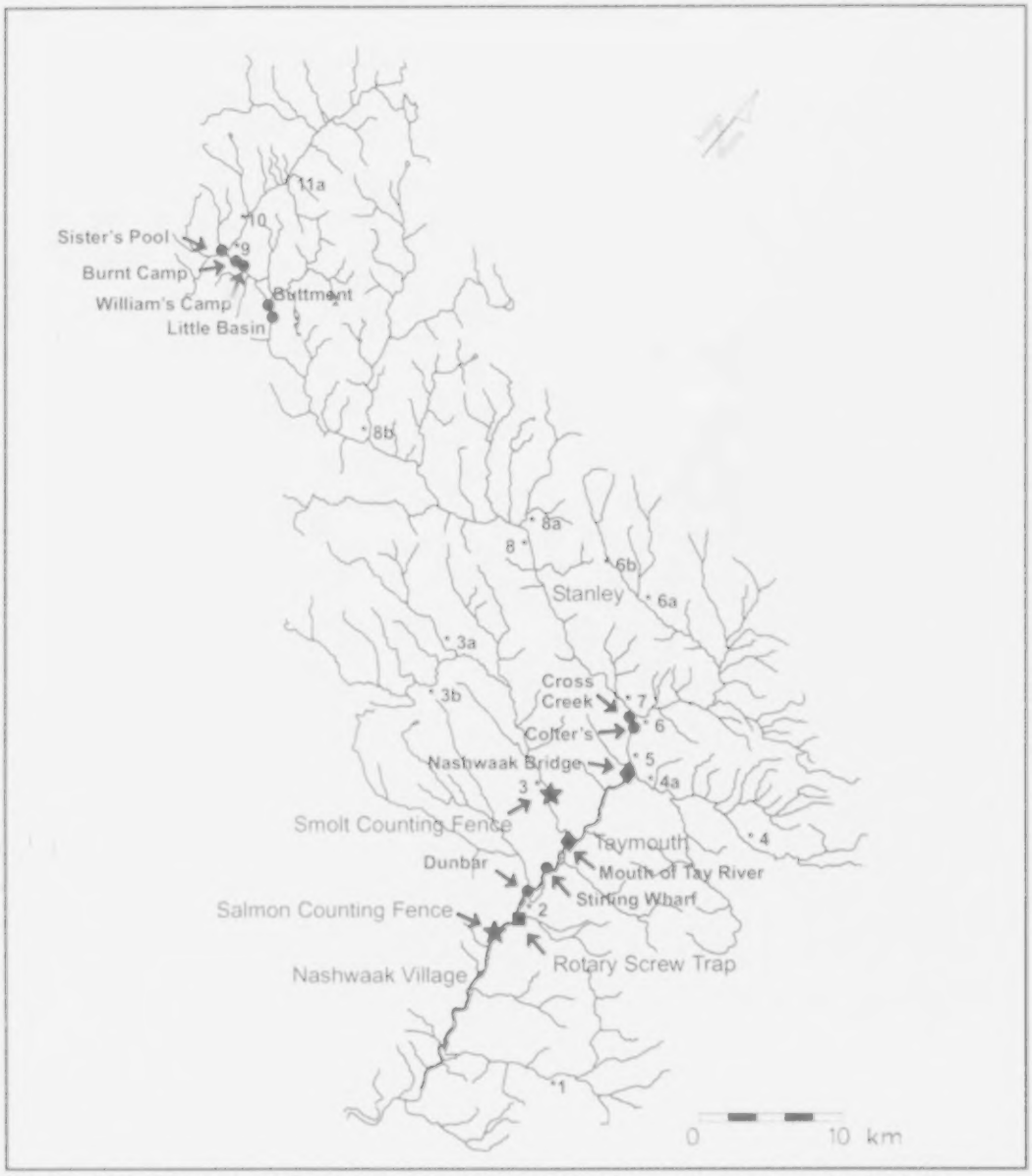


Fig. 16. Map of Nashwaak River, indicating adult counting fence site (star), smolt wheel site (square), smolt fence (star), seined pools (circles), and electrofishing sites (*).

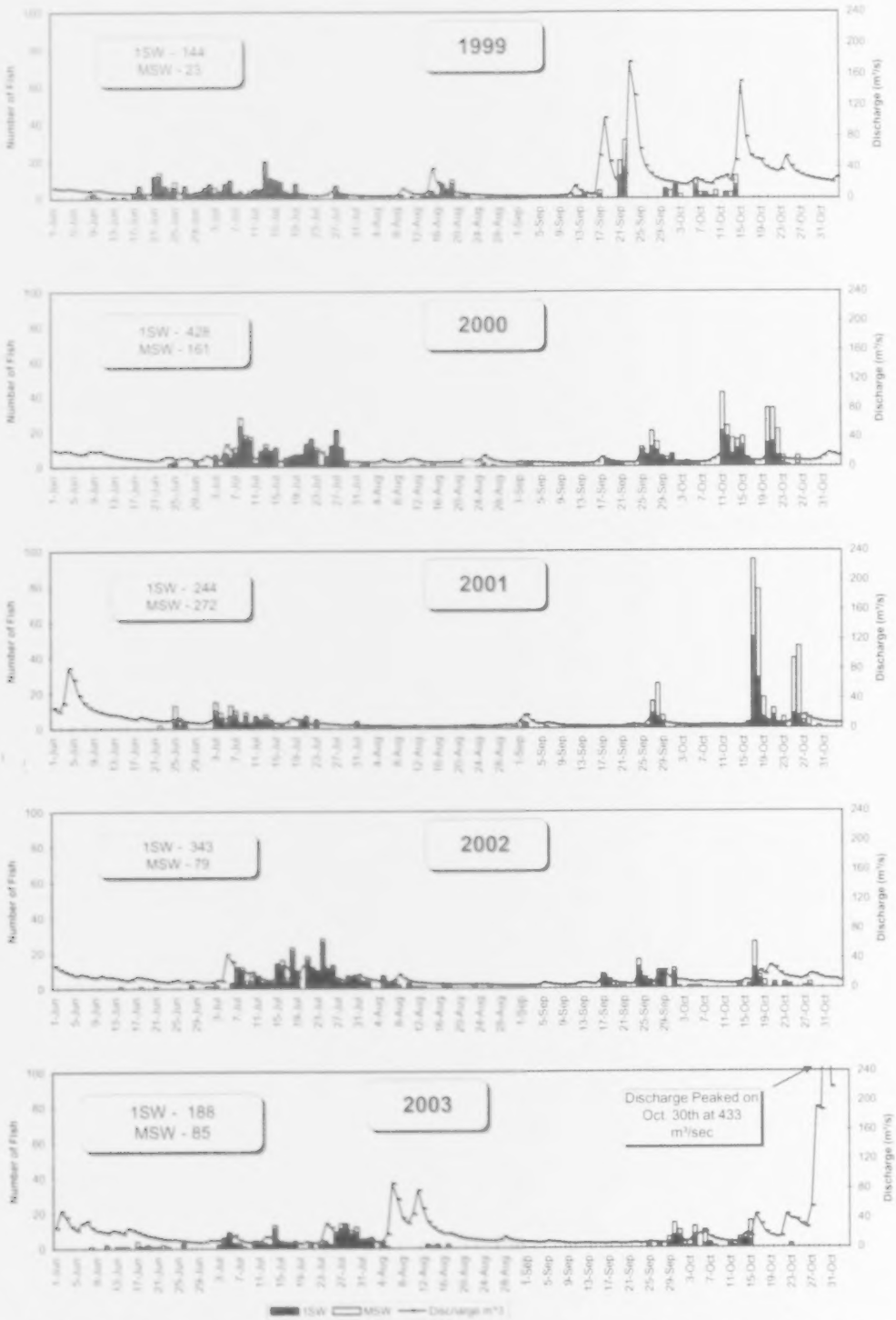


Fig. 17. Average daily discharge (m³/sec) at Durham Bridge and adjusted fence counts of 1SW and MSW salmon, Nashwaak River, 1999 - 2003.

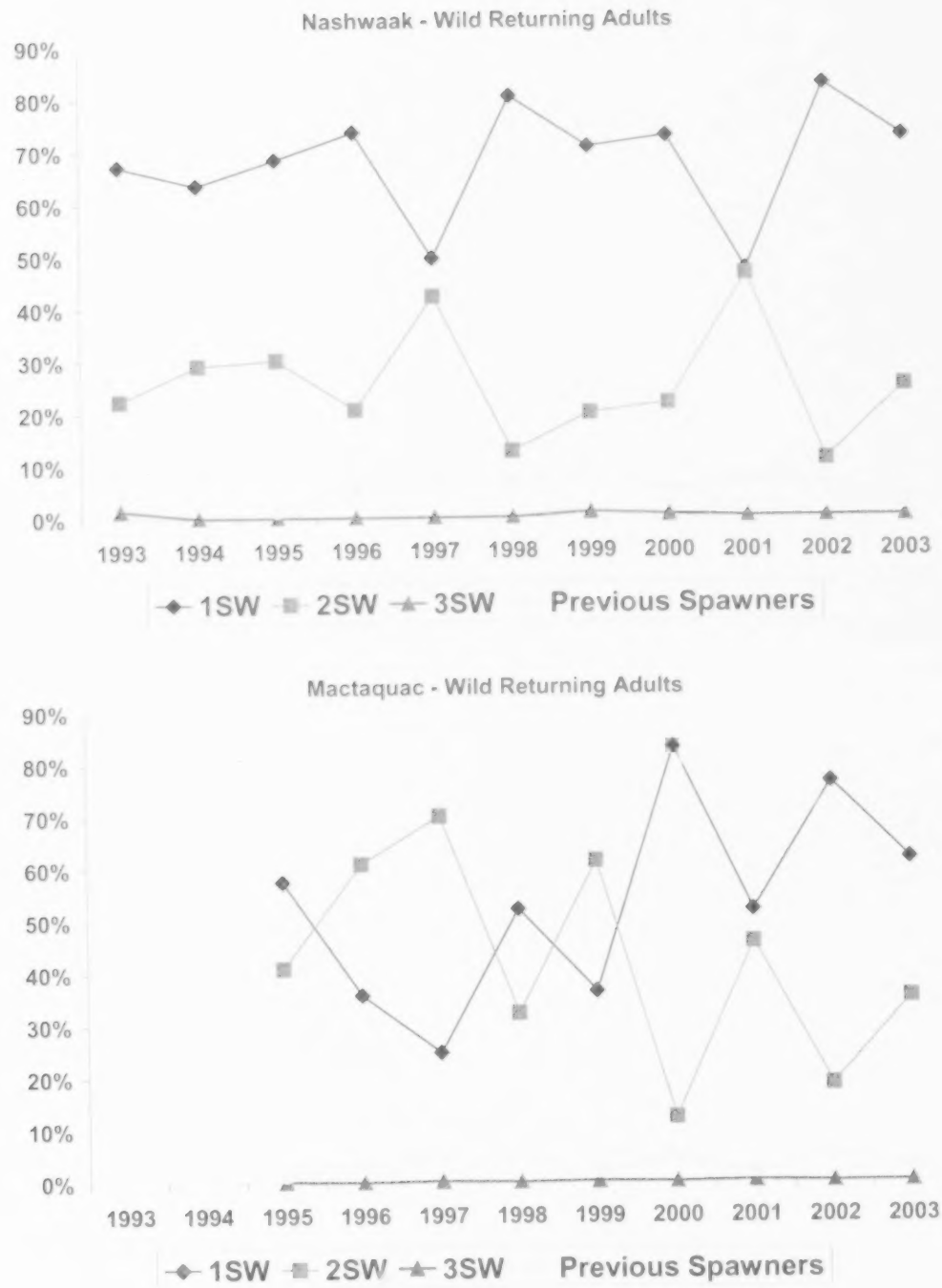
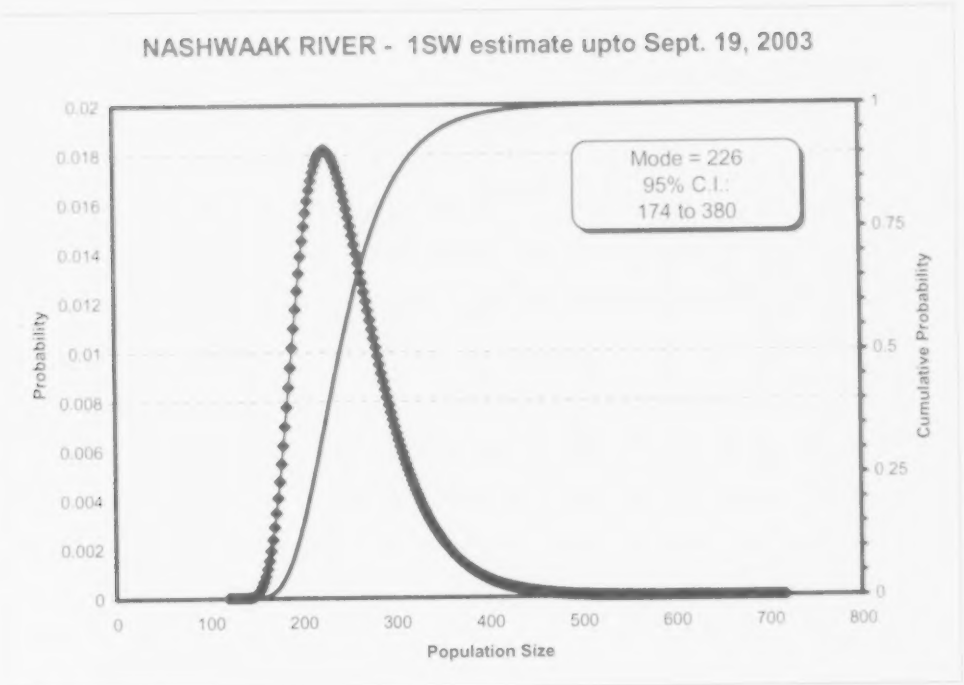


Fig. 18. The percentages of wild virgin 1SW, 2SW, 3SW and previous spawning (repeat spawning) Atlantic salmon in the total returns to the Nashwaak River, from 1993 to 2003 and to Mactaquac, from 1995 to 2003.



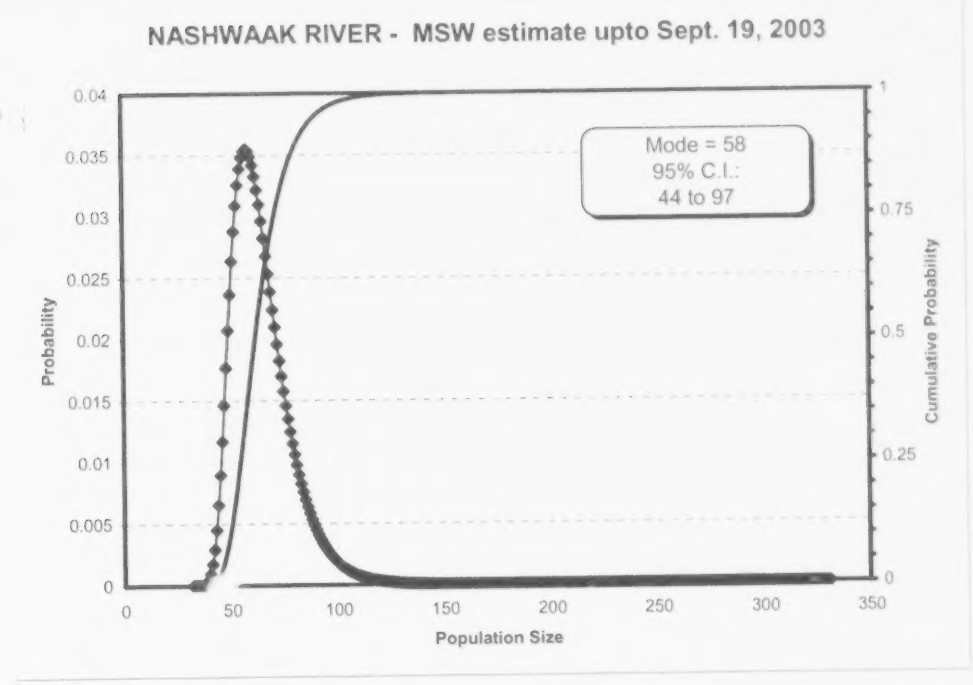


Fig. 19. Probability density (dots) and cumulative probability (black line) for the number of 1SW and MSW salmon returning to the Nashwaak River up to September 19, 2003, based on mark-recapture techniques.

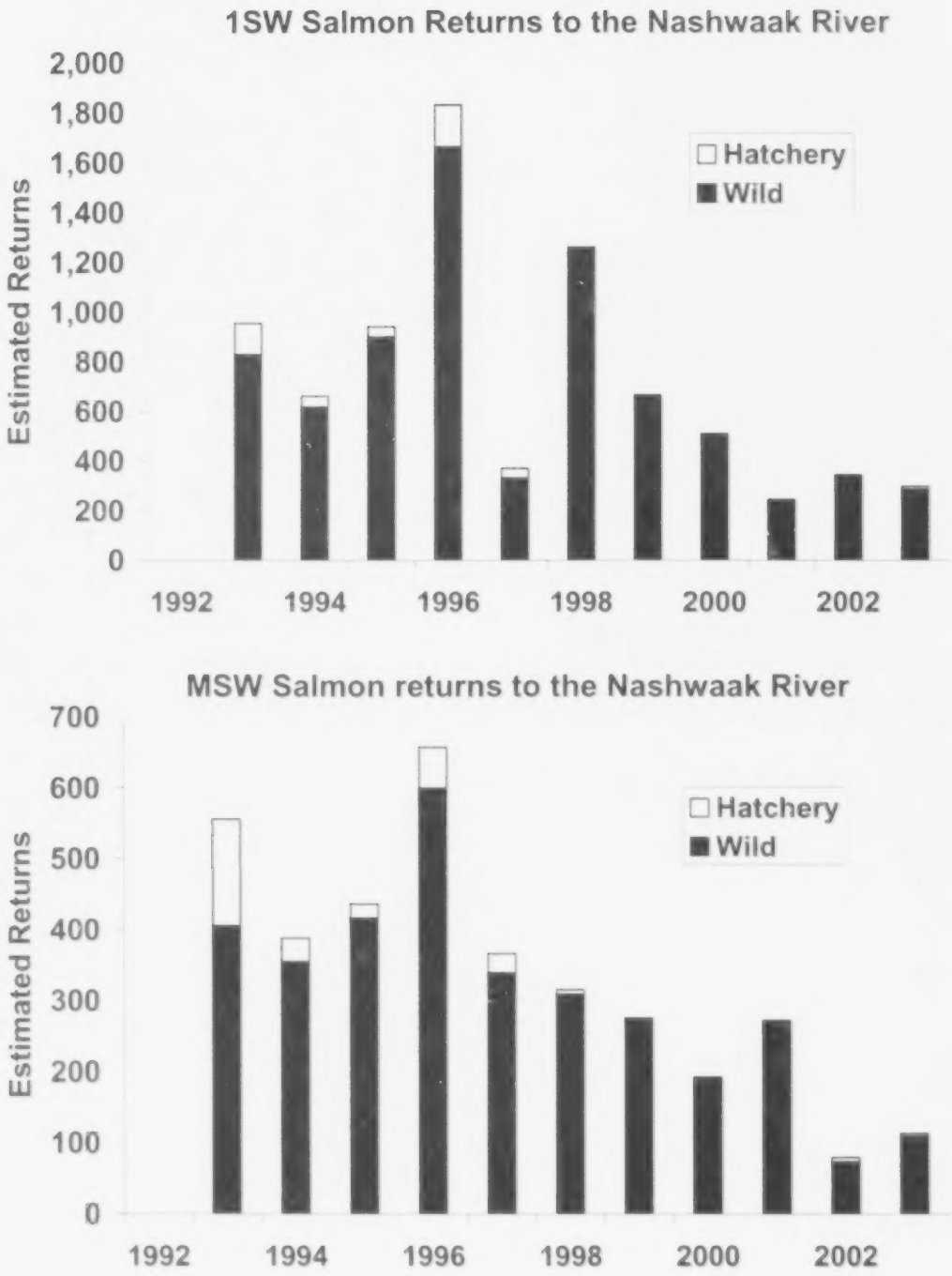


Fig. 20. Estimated wild and hatchery 1SW and MSW salmon returns to the Nashwaak River, 1993 to 2003.

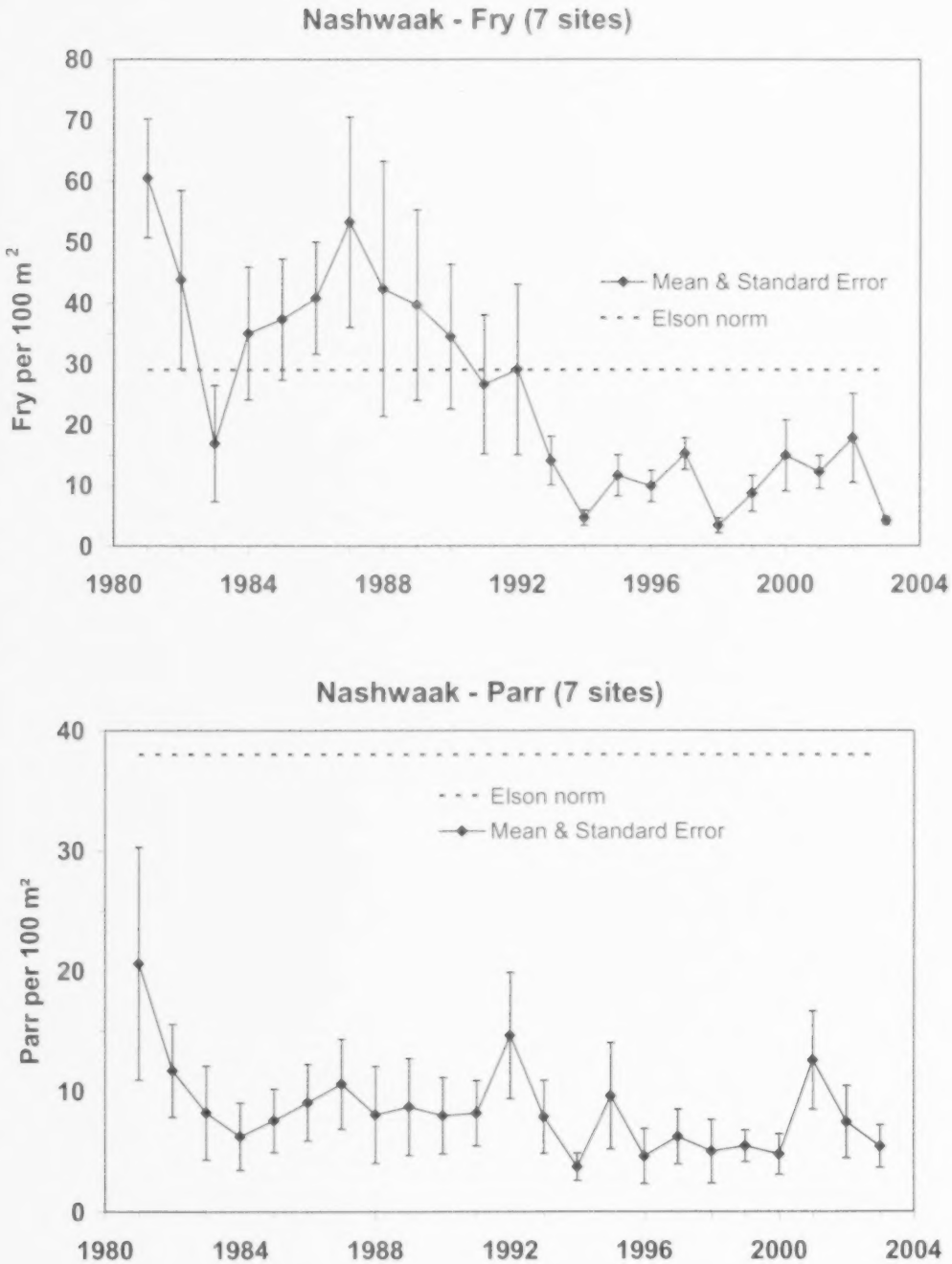


Fig. 21. Mean densities of age-0+ (fry) and age-1+ and older parr from electrofishing sites on the Nashwaak River in relation to the "Elson Norm" from 1981 to 2003.

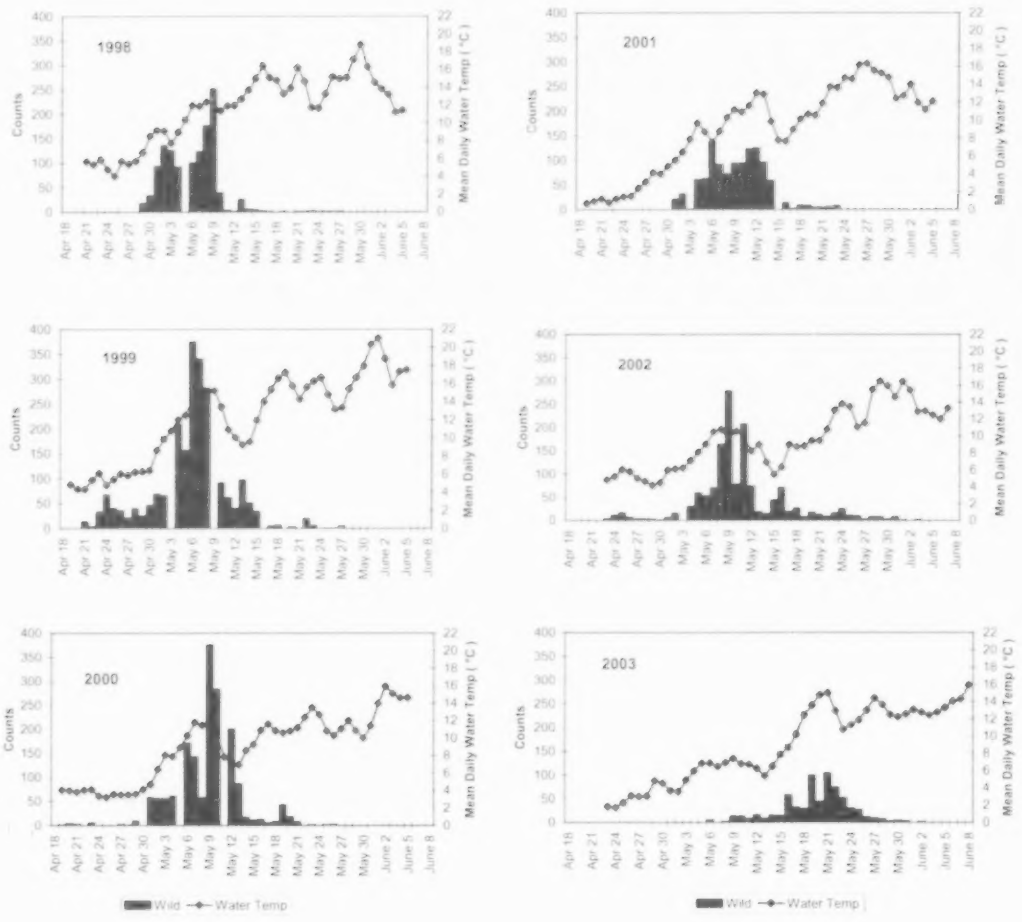


Fig. 22. Daily mean water temperatures (°C) and catches of wild smolts, Nashwaak River, 1998 – 2003.

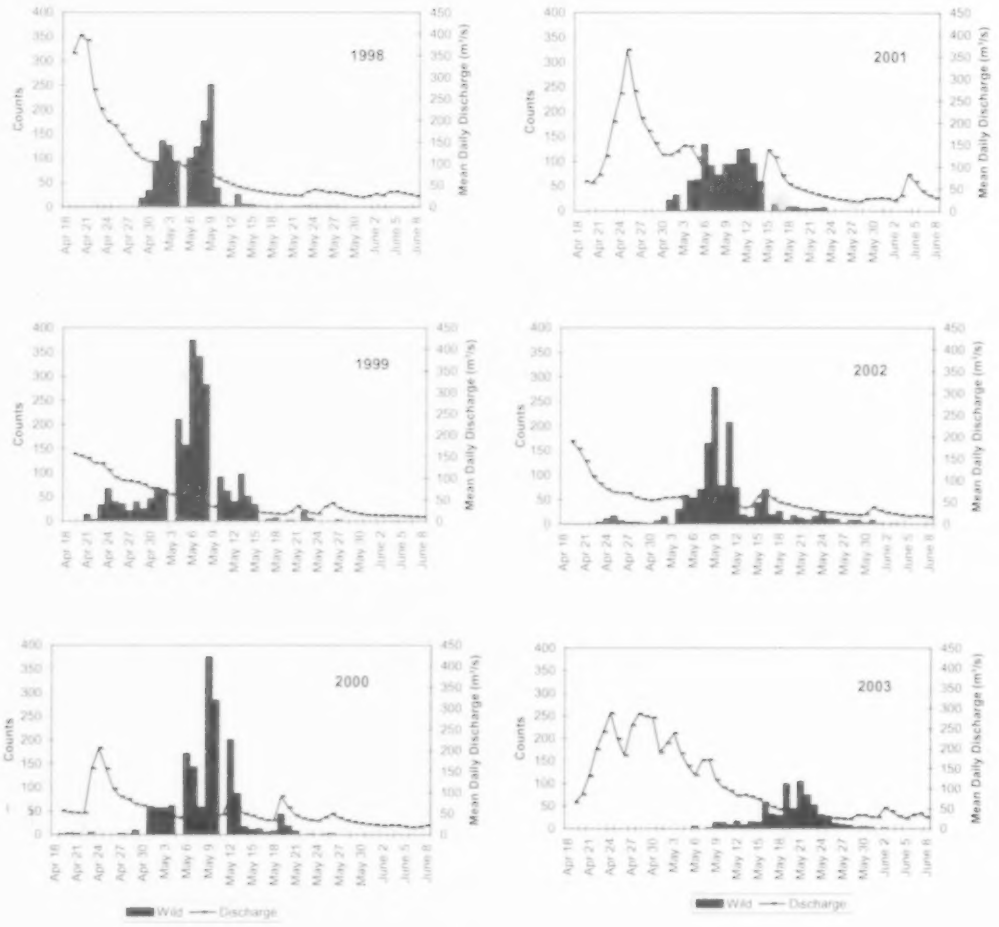


Fig. 23. Daily mean water discharge (m^3/sec) and catches of wild smolts, Nashwaak River, 1998 – 2003.

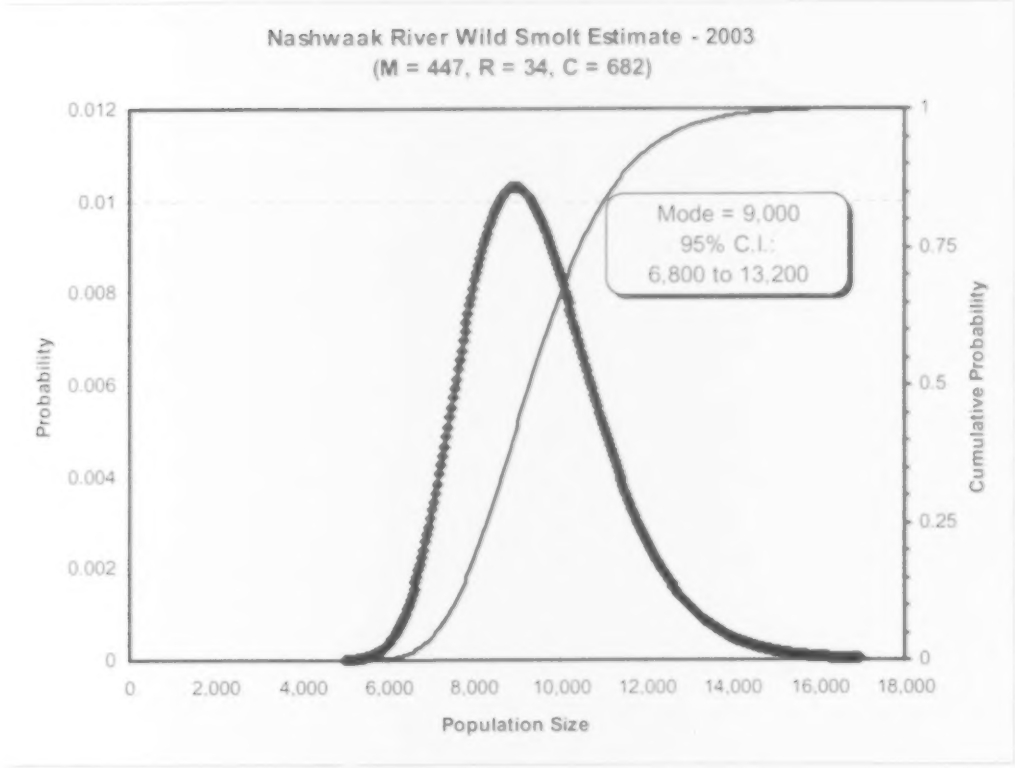


Fig. 24. Probability density (dots) and cumulative probability (black line), estimated using mark-recapture techniques, for the number for the number of wild Atlantic salmon smolts emigrating from the Nashwaak River, 2003.

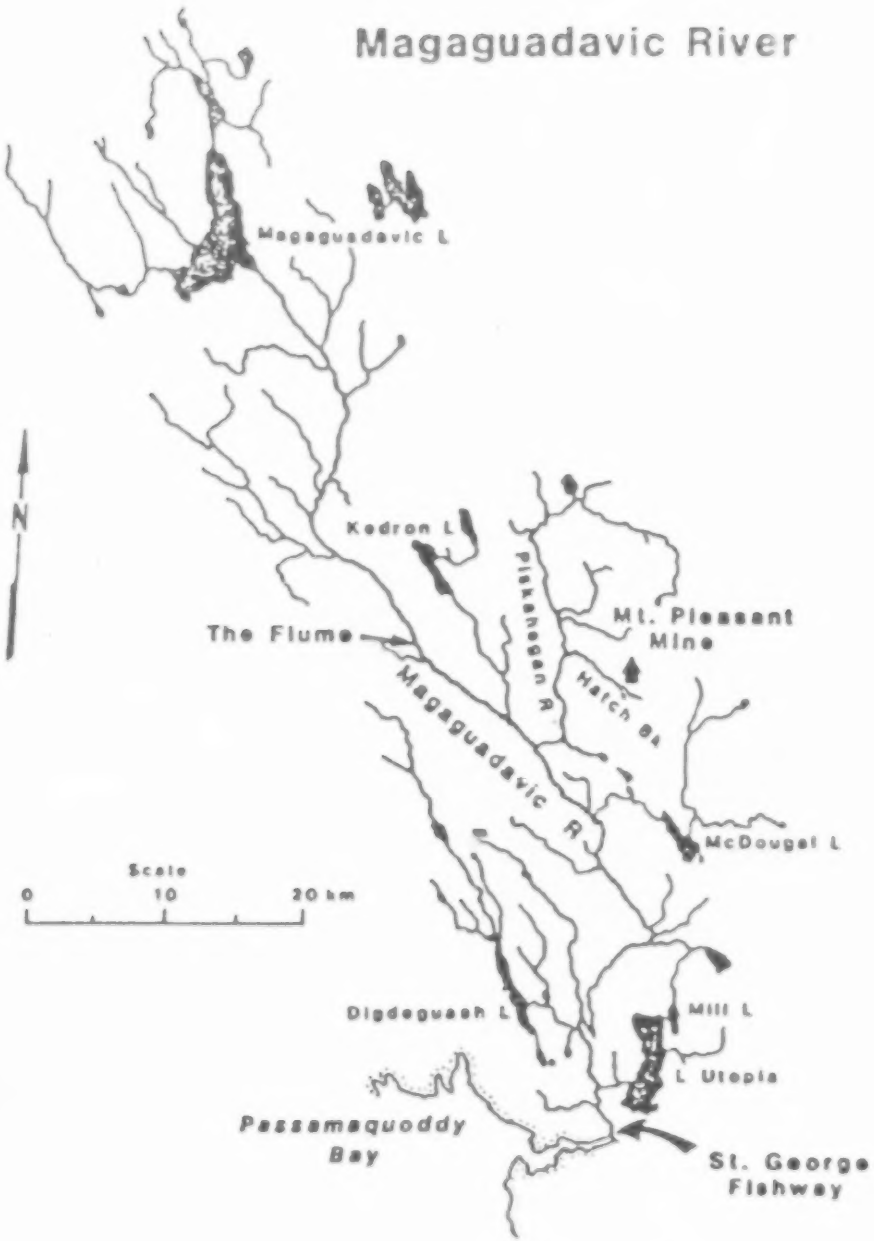


Fig. 25. Map of the Magaguadavic Watershed.

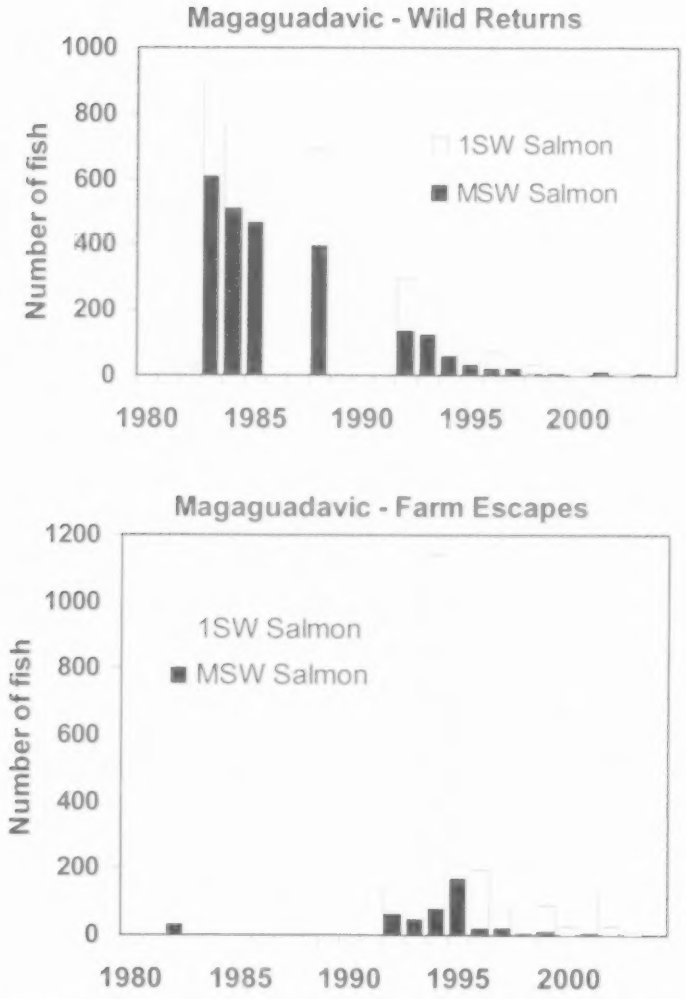


Fig. 26. The number of wild and aquaculture 1SW and MSW salmon returns to the Magaguadavic River.

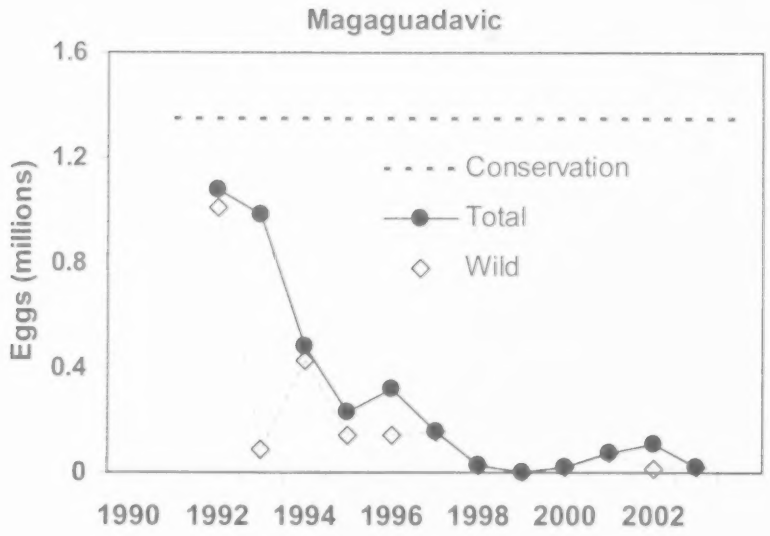


Fig. 27. Estimated egg depositions from 1SW and MSW salmon released upstream of the fishway in the Magaguadavic River from 1992 to 2003.

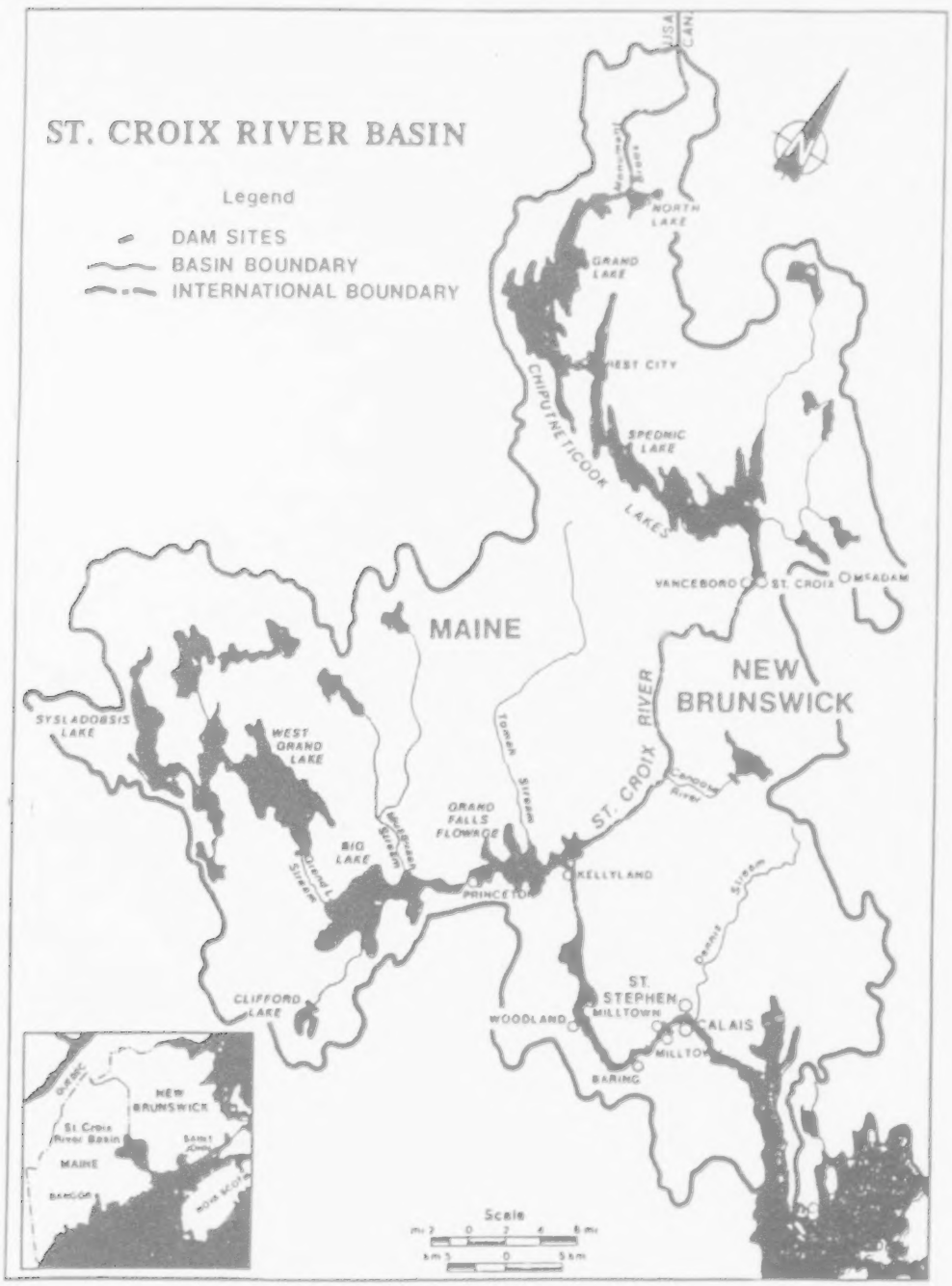


Fig. 28. Map of St. Croix Watershed.

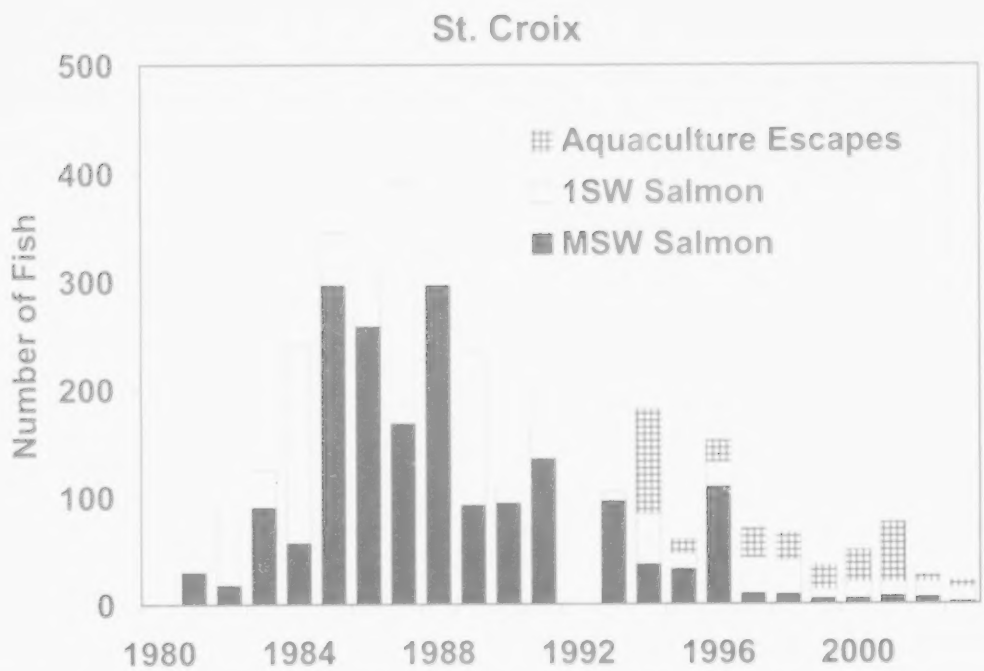


Fig. 29. The number of aquaculture escapes, 1SW and MSW salmon returns to the St. Croix River.

Appendix *i*. Numbers of juvenile hatchery salmon distributed to sites upstream of Mactaquac Dam (excluding distributions to the Aroostook River), 1976 - 2003. Fry are between zero to 14 weeks old, 0+ parr are at least 14 weeks old but less than one year old and 1+ parr are at least one year old but less than two years old.

	0+ Fry		0+ Parr		1+ Parr			1 yr smolt			2 yr smolt		
Year	No Mark	Ad Clip	No Mark	Ad Clip	No Mark	Ad Clip	Tagged	No Mark	Ad Clip	Tagged	No Mark	Ad Clip	Tagged
1976						52,662	5,000						
1977			6,042	44,021									
1978			9,163										
1979													
1980													5,995
1981													5,998
1982			75,210										
1983													
1984			123,757	8,517									
1985			164,947	110,569	24,544								
1986	17,300		126,692	91,808									
1987	266,257		101,052	50,283									
1988	79,948		107,478	60,472									
1989	150,384		151,562					4,680	30,011		20,000		
1990	164,005		232,291					2,877	24,026			17,140	
1991	227,535		499,130						30,181			19,646	
1992	600,408		514,662										
1993	672,797		272,824	99,939				819					
1994	983,549	30,000	285,988	253,730									
1995	642,830		193,208	226,391									
1996	940,962		511,771										
1997	504,488		391,860	20,991									
1998	213,973			282,491									
1999	172,220			356,635									
2000	609,802			371,751					1,996				
2001	8,330			344,618									
2002	500			342,176						2,357			
2003	2,723			261,852						1,483			
Total	6,258,011	30,000	3,767,637	2,926,244	24,544	52,662	5,000	8,376	86,214	3,840	20,000	36,786	11,993

Appendix *ii*. Adjusted counts, by age, of wild and hatchery 1SW and MSW salmon to Mactaquac Dam, 1995 - 2003.

Category Origin	Smolt.Sea Age	1995	1996	1997	1998	1999	2000	2001	2002	2003
1SW Salmon										
Wild	2.1	957	601	150	147	150	823	485	368	270
	3.1	1,154	585	146	185	290	459	191	258	103
	4.1	43	28	32	7	27	48	3	2	4
Wild	Total	**2,154**	**1,214**	**328**	**338**	**467**	**1,330**	**679**	**628**	**377**
Hatchery	1.1	1,509	2,649	1,543	2,112	1,672	1,403	839	1,358	815
	2.1	834	1,354	521	968	480	207	129	263	83
	3.1	483	867	627	1,459	569	66	35	86	13
	4.1	2	69	88	56	36	32	1	0	1
Hatchery	Total	**2,828**	**4,939**	**2,778**	**4,595**	**2,757**	**1,708**	**1,004**	**1,707**	**912**
1SW Salmon	**Total**	**4,982**	**6,153**	**3,106**	**4,933**	**3,224**	**3,038**	**1,683**	**2,335**	**1,289**
MSW Salmon										
Wild	2.2	976	1,128	428	64	359	137	507	124	160
	3.2	523	925	473	145	412	58	91	29	55
	4.2	35	13	26	1	16	2	1	0	0
	Previous Spawners & 3SW	59	114	68	101	28	73	29	41	19
Wild	Total	**1,593**	**2,181**	**995**	**312**	**816**	**270**	**628**	**194**	**234**
Hatchery	1.2	398	567	412	229	554	173	462	142	443
	2.2	95	221	143	120	209	57	49	22	38
	3.2	47	137	158	177	158	19	9	2	10
	4.2	2	10	4	13	3	1	0	0	0
	Previous Spawners & 3SW	30	13	26	92	19	10	28	7	7
Hatchery	Total	**572**	**947**	**744**	**631**	**943**	**260**	**548**	**173**	**498**
MSW Salmon	**Total**	**2,165**	**3,128**	**1,739**	**943**	**1,759**	**530**	**1,176**	**367**	**732**
Total	**Total**	**7,147**	**9,281**	**4,845**	**5,876**	**4,983**	**3,568**	**2,859**	**2,702**	**2,021**

Appendix *iii*. Numbers of juvenile hatchery salmon distributed to sites within the Nashwaak River, 1976 - 2003. Fry are between zero to 14 weeks old, 0+ parr are at least 14 weeks old but less than one year old and 1+ parr are at least one year old but less than two years old.

	0+ Fry		0+ Parr		1+ Parr		1+ Smolt			2+ Smolt		
Year	No Mark	Ad Clip	No Mark	Ad clip	No Mark	Ad Clip	No Mark	Ad clip	Tagged	No Mark	Ad Clip	Tagged
1976	203,265		18,964		11,117	1,210						
1977	137,187	650	22,044		7,200	3,196						
1978			106,375		1,320							
1979			85,113		22,476							
1980	134,884				18,240							
1981					25,254	32,880				20,336		
1982			57,750							5,183	12,776	
1983											8,053	7,998
1984			47,129								12,158	8,005
1985	11,000		13,043		46,643	12,344			7,966			
1986			23,071				18,734					
1987	71,614		17,931				13,205		6,500			
1988	121,711		17,114				16,788		4,001			
1989	13,703		50,508				11,914					
1990	47,172		25,568				15,248		3,999			
1991	16,397		18,102				15,903		4,000			
1992	26,302		26,553				9,658		3,995			
1993	17,310		22,500				9,270		3,881			
1994	51,320		16,917				11,059		4,000			
1995	32,450		16,802				6,633		6,648			
1996							9,027	a	3,004			
1997												
1998												
1999	2,500			6,000								
2000	8,424			6,000								
2001	7,009			11,713								
2002				3,837					2,148			
2003	2,693		7,000	21,491				4,918	1,780			
Total	**904,941**	**650**	**592,384**	**49,041**	**132,250**	**49,630**	**137,439**	**4,918**	**51,922**	**25,519**	**32,987**	**16,003**

a - 3,014 one year old smolt were released from the Mactaquac Migration Channel.

Appendix *iv*. Numbers of juvenile hatchery salmon distributed to sites within the Magaguadavic River, 1976 - 2003. Fry are between zero to 14 weeks old, 0+ parr are at least 14 weeks old but less than one year old and 1+ parr are at least one year old but less than two years old.

	0+ Fry		0+ Parr		1+ Parr		1+ Smolt			2+ Smolt		
Year	No Mark	Ad Clip	No Mark	Ad clip	No Mark	Ad Clip	No Mark	Ad clip	Tagged	No Mark	Ad Clip	Tagged
1976												
1977												
1978												
1979												
1980												
1981												
1982												
1983												
1984												
1985												
1986												
1987			14,644									
1988							2,034					
1989										5,771	5,000	
1990												
1991												
1992												
1993												
1994												
1995												
1996												
1997				2,767								
1998												
1999												
2000												
2001												
2002	29,033											
2003	20,556		5,000	7,336								
Total	**49,589**	-	**19,644**	**10,103**	-	-	**2,034**	-	-	5,771	5,000	-

Appendix v. Numbers of juvenile hatchery salmon distributed to sites within the St. Croix River, 1976 - 2003. Fry are between zero to 14 weeks old, 0+ parr are at least 14 weeks old but less than one year old and 1+ parr are at least one year old but less than two years old.

		0+ Fry		0+ Parr		1+ Parr		1+ Smolt			2+ Smolt		
Year	origin	No Mark	Ad Clip	No Mark	Ad clip	No Mark	Ad Clip	No Mark	Ad clip	Tagged	No Mark	Ad Clip	Tagged
1976													
1977													
1978													
1979													
1980													
1981					9,800								
1982													
1983													
1984													
1985													
1986													
1987													
1988													
1989													
1990													
1991	Penobscot	51,025			40,001				60,205				
1992	Penobscot	85,307			71,474				50,342				
1992	St. Croix												
1993	St. Croix												
1993	Penobscot				100,950				40,110				
1994	St. Croix			38,600									
1994	Penobscot	87,200							60,600				
1995	St. Croix			20,962					17,537				
1995	Penobscot	400											
1996	St. Croix	1,525			52,120				15,583				
1996	Penobscot	364											
1997	St. Croix	1,025		103,000			19,720						
1997	Penobscot	1,236			400								
1998	St. Croix	520			31,870								
1998	Penobscot	1,553											
1999	St. Croix	580			22,450								
1999	Penobscot	1,406							21,314				
2000	St. Croix	145			18,963								
2000	Penobscot	1,266							19,984				
2001	St. Croix	300		6,299									
2001	Penobscot	834							8,146				
2002	St. Croix	197		15,404									
2002	Penobscot	1,320							4,147				
2003	St. Croix	215		16,779									
2003	Penobscot	656							3,232				
Total		**237,074**	-	**201,044**	**348,028**	-	**19,720**	-	**301,200**	-	-	-	-